UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Northwest Region
7600 Sand Point Way N.E., Bldg. 1
Seattle, WA 98115

Refer to:
2000/01120

November 25, 2003

Mr. Lawrence C. Evans
U.S. Army Corps of Engineers
Attn: Susan Sturgess
Regulatory Branch, CENWP-OP-G
P.O. Box 2946
Portland, OR 97208-2946

Re: Endangered Species Act Section 7 Formal Consultation and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation for the City of Rainier Boat Ramp Project in the Columbia River, Columbia County, Oregon (Corps No. 200000058)

Dear Mr. Evans:

On September 14, 2000, NOAA's National Marine Fisheries Service (NOAA Fisheries) received a letter from the Corps of Engineers (COE) requesting informal consultation under the Endangered Species Act (ESA) on the issuance of a permit to the City of Rainier (Corps permit number 200000058) for construction of a boat ramp in the Columbia River at Rainier, Oregon. The proposed action is to remove the existing boat ramp and construct a new one downstream at river mile 67.2 of the Columbia River.

Enclosed is NOAA Fisheries' biological opinion (Opinion) on the proposed action. In this Opinion, NOAA Fisheries concludes that the proposed new boat ramp facility will not jeopardize the existence of ESA listed salmon and steelhead, nor result in the adverse modification of designated critical habitats for Snake River sockeye salmon, Snake River fall-run chinook salmon and Snake River spring/summer-run chinook salmon. Pursuant to section 7 of the ESA, NOAA Fisheries included reasonable and prudent measures in the Opinion that NOAA Fisheries believes will minimize take of listed species.

This Opinion addresses Snake River sockeye salmon (*Oncorhynchus nerka*), Snake River fall chinook salmon (*O. tshwaytscha*), Snake River spring/summer chinook salmon, Upper Columbia River spring-run chinook salmon, Lower Columbia River chinook salmon, Columbia River chum salmon (*O. keta*), Snake River steelhead (*O. mykiss*), Upper Columbia River steelhead, Middle Columbia River steelhead, Lower Columbia River steelhead, Upper Willamette River chinook salmon, and Upper Willamette River steelhead and constitutes formal consultation for these listed species.

This document also serves as consultation on essential fish habitat for starry flounder (*Platichthys stellatus*), and coho (*O. kisutch*) and chinook salmon under the Magnuson-Stevens Fishery Conservation and Management Act and its implementing regulations (50 CFR Part 600).

Questions regarding this Opinion should be directed to Ben Meyer of my staff in the Oregon Habitat Branch at 503/230-5425.

Sincerely,

for Michael R Crouse

D. Robert Lohn
Regional Administrator

Endangered Species Act - Section 7 Consultation
Biological Opinion

&

Magnuson-Stevens Fishery Conservation and Management Act
Essential Fish Habitat Consultation

City of Rainier Boat Ramp Project in the Columbia River,
Columbia County, Oregon
(Corps No. 200000058)

Agency: U.S. Army Corps of Engineers

Consultation
Conducted By: NOAA's National Marine Fisheries Service,
Northwest Region

Date Issued: November 25, 2003

Issued by: for Michael R Crouse
D. Robert Lohn
Regional Administrator

Refer to: **2000/01120**

TABLE OF CONTENTS

1. ENDANGERED SPECIES ACT

1.1 Background

On September 14, 2000, NOAA's National Marine Fisheries Service (NOAA Fisheries) received a request from Portland District Army Corps of Engineers (COE) for Endangered Species Act (ESA) section 7 informal consultation for issuance of a COE permit (Corps No. 200000058) for a boat ramp construction project in the Columbia River at Rainier, Oregon. In the biological assessment (BA) attached to the September 14, 2000, request, the COE determined that the Snake River (SR) sockeye salmon (*Oncorhynchus nerka*), SR spring/summer-run chinook salmon (*O. tshawytscha*), SR fall-run chinook salmon, Lower Columbia River (LCR) steelhead (*O. mykiss*), Upper Columbia River (UCR) steelhead, SR Basin steelhead, Middle Columbia River (MCR) steelhead, Columbia River (CR) chum salmon (*O. keta*), LCR chinook salmon, UCR spring-run chinook salmon, Upper Willamette River (UWR) steelhead, and UWR chinook salmon occur within the project area and were not likely to be adversely affected by the proposed project.

On October 19, 2000, NOAA Fisheries responded with a letter indicating that we did not concur with the COE's effects determination. In that letter, NOAA Fisheries also requested initiation of formal consultation and described information necessary to complete that consultation. NOAA Fisheries received additional information on May 8, 2001. Concerns raised by NOAA Fisheries about the project resulted in additional meetings and suggestions for design changes that would avoid or minimize the adverse effects of the project. The applicant at that time declined to propose any further conservation measures.

On October 18, 2002, NOAA Fisheries shared a draft biological opinion with COE and the applicant. That draft determined that as proposed, the project would result in jeopardy to certain listed species and adverse modification of designated critical habitat. Several subsequent meetings with the applicant and COE resulted in the applicant indicating that a revision in the project would be submitted. On July 31, 2003, NOAA Fisheries received a revised set of drawings and description of the project. The proposed rock groin that would act as a barrier to salmonid migration was replaced with a soldier pile barrier that should provide passage. This was an important change that will reduce adverse affects associated with the project.

NOAA Fisheries prepared this biological opinion (Opinion) to analyze the effects of the proposed action on the subject species. The objective of this Opinion is to determine whether the COE's issuance of a permit for the proposed boat ramp facility is likely to jeopardize the continued existence of the above listed species or destroy or adversely modify critical habitats. References and dates regarding the listing status, critical habitat designations and ESA section 4(d) take prohibitions are listed in Table 1.

Table 1. References for additional background on listing status, biological information, and critical habitat elements for the listed and proposed species addressed in this biological and conference opinion.

Species	Listing Status	Critical Habitat	Protective Regulations	Biological Information
CR chum salmon	March 25, 1999; 64 FR 14508, Threatened		July 10, 2000; 65 FR 42422	Johnson *et al.* 1997; Salo 1991
LCR steelhead	March 19, 1998; 63 FR 13347, Threatened		July 10, 2000; 65 FR 42422	Busby *et al.* 1995; 1996
MCR steelhead	March 25, 1999; 64 FR 14517, Threatened		July 10, 2000; 65 FR 42422	Busby *et al.* 1995; 1996
UCR steelhead	August 18, 1997; 62 FR 43937, Endangered		July 10, 2000; 65 FR 42422	Busby *et al.* 1995; 1996
SR Basin steelhead	August 18, 1997; 62 FR 43937, Threatened		July 10, 2000; 65 FR 42422	Busby *et al.* 1995; 1996
SR sockeye salmon	November 20, 1991; 56 FR 58619, Endangered	December 28, 1993; 58 FR 68543	November 20, 1991; 56 FR 58619	Waples *et al.* 1991a; Burgner 1991
LCR chinook salmon	March 24, 1999; 64 FR 14308, Threatened		July 10, 2000; 65 FR 42422	Myers *et al.*1998; Healey 1991
UCR spring-run chinook salmon	March 24, 1999; 64 FR 14308, Endangered		July 10, 2000; 65 FR 42422	Myers *et al.*1998; Healey 1991
SR spring/summer-run chinook salmon	April 22, 1992; 57 FR 34653, Threatened	December 28, 1993; 58 FR 68543	April 22, 1992; 57 FR 14653	Matthews and Waples 1991; Healey 1991
SR fall-run chinook salmon	April 22, 1992; 57 FR 34653, Threatened	December 28, 1993; 58 FR 68543	April 22, 1992; 57 FR 14653	Waples *et al.* 1991b; Healey 1991
UWR chinook salmon	March 24, 1999, 64 FR 14308 Threatened		July 10, 2000; 65 FR 42422	Myers *et al.*1998; Healey 1991; ODFW and WDFW 1998
UWR steelhead	March 25, 1999, 64 FR 14517 Threatened		July 10, 2000; 65 FR 42422	Busby *et al.* 1995; Busby *et al.* 1996; ODFW and WDFW 1998

NOAA Fisheries concludes in this Opinion that effects of the new boat ramp, when added to the existing environmental baseline (which includes significant adverse effects to listed species from aquatic habitat degradation, and increased predation), and taken together with likely future boating activities, would not jeopardize the continued existence of listed Snake and Columbia River salmon, and nor destroy or adversely modify critical habitats.

1.2 Proposed Action

The proposed action is the issuance of permits to authorize removal of an existing boat ramp at Columbia River mile 67.9 and the construction of a new ramp and associated structures at river mile 67.2. Work at the existing ramp would entail the removal of a 30-foot by 150-foot concrete ramp and placement of 840 cubic yards of fill to restore the bankline to its preexisting elevation and contour. The restored bankline would be planted with native vegetation.

Action at the site of the new ramp would entail: (1) Installation of a two-lane concrete boat ramp; (2) installation of a 150-foot soldier pile (16 steel piles) bulkhead extending into the river; (3) placement of riprap along the new ramp; (4) installation of a 6-foot by 160-foot wooden boarding float, a 12-foot by 140-foot concrete breakwater/transient float, and 19 steel piles to support a L-shaped dock structure approximately 140-foot feet from shore at ordinary high water (OHW); and (5) construction of an asphalt parking lot with concrete curb and restroom are proposed.

1.3 Biological Information and Critical Habitat

The action area is defined by NOAA Fisheries regulations (50 CFR 402) as "all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action." The Columbia River at this site serves as a migration area for all listed species under consideration in this Opinion. It may also serve as a feeding and rearing area for juvenile chum and sub-yearling chinook salmon. Essential features of the areas for the species are: (1) Substrate; (2) water quality; (3) water quantity; (4) water temperature; (5) water velocity; (6) cover/shelter; (7) food (juvenile only); (8) riparian vegetation; (9) space; and (10) safe passage conditions (50 CFR 226). The essential features this proposed project may affect are water quality resulting from construction activities, stormwater discharge and boating activities; food production from loss of habitat; and water velocity and safe passage conditions as a result of the structures placed in the river and boating activities.

For the purposes of this Opinion, the action area is defined as the area within a 100-foot radius of the old ramp (river mile 67.9), the new ramp (river mile 67.2), upstream of the new ramp to Fox Creek, and downstream to the limits of short-term visible turbidity in the Columbia River at Rainier, Oregon. The action area also includes designated critical habitat for SR sockeye salmon, SR spring/summer and fall chinook salmon affected by the proposed action at the old boat ramp and new ramp in the Columbia River.

Based on migratory timing, NOAA Fisheries expects that few adult or juvenile salmonids would be present in the action area during the proposed in-water work period. Listed juvenile steelhead and salmon would occur in the area after construction is completed. The proposed action would occur within designated critical habitat for listed species.

1.4 Evaluating Proposed Actions

The standards for determining jeopardy are set forth in section 7(a)(2) of the ESA as defined by 50 CFR Part 402 (the consultation regulations). In conducting analyses of habitat-altering actions under section 7 of the ESA, NOAA Fisheries uses the following steps of the consultation regulations combined with the Habitat Approach (NMFS 1999): (1) Consider the status and biological requirements of the species; (2) evaluate the relevance of the environmental baseline in the action area to the species' current status; (3) determine the effects of the proposed or continuing action on the species and whether the action is consistent with the available recovery strategy; (4) consider cumulative effects; and (5) determine whether the proposed action, in light of the above factors, is likely to appreciably reduce the likelihood of species survival in the wild or destroy or adversely modify critical habitat. In completing this step of the analysis, NOAA Fisheries determines whether the action under consultation, together with cumulative effects when added to the environmental baseline, is likely to jeopardize the ESA-listed species or result in the destruction or adverse modification of critical habitat. If either or both are found, NOAA Fisheries will identify reasonable and prudent alternatives for the action that avoid jeopardy or destruction or adverse modification of critical habitat.

1.4.1 Biological Requirements

The first step in the methods NOAA Fisheries uses for applying the ESA section 7(a)(2) to listed salmon is to define the species' biological requirements that are most relevant to each consultation. NOAA Fisheries also considers the status of the listed species taking into account population size, trends, distribution and genetic diversity. To assess to the status of the listed species, NOAA Fisheries starts with the determinations made in its decision to list the species for ESA protection and also considers new data available that is relevant to the determination (Myers *et al.* 1998).

Additional background on listing status, biological information, and critical habitat elements for these 14 listed ESUs are described below. Information presented here for Columbia Basin ESUs is adapted from Appendix A to the paper "A Standardized Quantitative Analysis of the Risks Faced by Salmonids in the Columbia River Basin" (McClure *et al.* 2000a). Further details regarding the life histories, factors for decline, and range-wide status of these species are found in NMFS (2000).

<u>SR Fall-Run Chinook Salmon</u>
The Snake Basin drains an area of approximately 280,000 square kilometers (km^2) and incorporates a range of vegetative life zones, climatic regions, and geological formations, including the deepest canyon (Hells Canyon) in North America. The ESU includes the mainstem

river and all tributaries, from their confluence with the Columbia River to the Hells Canyon Dam complex. Because genetic analyses indicate that fall-run chinook salmon in the Snake River are distinct from the spring/summer-run in the Snake River Basin (Waples *et al.* 1991a), SR fall-run chinook salmon are considered separately from the other two forms. They are also considered separately from those assigned to the UCR summer- and fall-run ESU because of considerable differences in habitat characteristics and adult ocean distribution and less definitive, but still significant, genetic differences. There is, however, some concern that recent introgression from Columbia River hatchery strays is causing the Snake River population to lose the qualities that made it distinct for ESA purposes.

SR fall-run chinook salmon remained stable at high levels of abundance through the first part of the twentieth century, but then declined substantially. Although the historical abundance of fall-run chinook salmon in the Snake River is difficult to estimate, adult returns appear to have declined by three orders of magnitude since the 1940s, and perhaps by another order of magnitude from pristine levels. Irving and Bjornn (1981) estimated that the mean number of fall-run chinook salmon returning to the Snake River declined from 72,000 during the period 1938 to 1949, to 29,000 during the 1950s. Further declines occurred upon completion of the Hells Canyon Dam complex, which blocked access to primary production areas in the late 1950s (see below).

Fall-run chinook salmon in this ESU are ocean-type. Adults return to the Snake River at ages 2 through 5, with age 4 most common at spawning (Chapman *et al.* 1991). Spawning, which takes place in late fall, occurs in the mainstem and in the lower parts of major tributaries (NWPPC 1989; Bugert *et al.* 1990). Juvenile fall-run chinook salmon move seaward slowly as subyearlings, typically within several weeks of emergence (Chapman *et al.* 1991). Based on modeling by the Chinook Technical Committee, the Pacific Salmon Commission estimates that a significant proportion of the SR fall-run chinook (about 36%) are taken in Alaska and Canada, indicating a far-ranging ocean distribution. In recent years, only 19% were caught off Washington, Oregon, and California, with the balance (45%) taken in the Columbia River (Simmons 2000).

With hydrosystem development, the most productive areas of the Snake River Basin are now inaccessible or inundated. The upper reaches of the mainstem Snake River were the primary areas used by fall-run chinook salmon, with only limited spawning activity reported downstream from river kilometer (Rkm) 439. The construction of Brownlee Dam (1958; Rkm 459), Oxbow Dam (1961; Rkm 439), and Hells Canyon Dam (1967; Rkm 397) eliminated the primary production areas of SR fall-run chinook salmon. There are now 12 dams on the mainstem Snake River, and they have substantially reduced the distribution and abundance of fall-run chinook salmon (Irving and Bjornn 1981).

The Snake River has contained hatchery-reared fall-run chinook salmon since 1981 (Busack 1991). The hatchery contribution to Snake River escapement has been estimated at greater than 47% (Myers *et al.* 1998). Artificial propagation is recent, so cumulative genetic changes associated with it may be limited. Wild fish are incorporated into the brood stock each year, which should reduce divergence from the wild population. Release of subyearling fish may also help minimize the differences in mortality patterns between hatchery and wild populations that can lead to genetic change (Waples 1999). (See NMFS [1999] for further discussion of the SR fall-run chinook salmon supplementation program.)

Some SR fall-run chinook historically migrated over 1,500 km from the ocean. Although the Snake River population is now restricted to habitat in the lower river, genes associated with the lengthier migration may still reside in the population. Because longer freshwater migrations in chinook salmon tend to be associated with more-extensive oceanic migrations (Healey 1983), maintaining populations occupying habitat that is well inland may be important in continuing diversity in the marine ecosystem as well.

For the SR fall-run chinook salmon ESU as a whole, NOAA Fisheries estimates that the median population growth rate (lambda) over the base period[1] ranges from 0.94 to 0.86, decreasing as the effectiveness of hatchery fish spawning in the wild increases compared to that of fish of wild origin (Tables B-2a and B-2b in McClure *et al.* 2000b).

SR Spring/Summer-run Chinook Salmon

The location, geology, and climate of the Snake River region create a unique aquatic ecosystem for chinook salmon. Spring-run and/or summer-run chinook salmon are found in several subbasins of the Snake River (CBFWA 1990). Of these, the Grande Ronde and Salmon Rivers are large, complex systems composed of several smaller tributaries that are further composed of many small streams. In contrast, the Tucannon and Imnaha Rivers are small systems with most salmon production in the main river. In addition to these major subbasins, three small streams (Asotin, Granite, and Sheep Creeks) that enter the Snake River between Lower Granite and Hells Canyon Dams provide small spawning and rearing areas (CBFWA 1990). Although there are some indications that multiple ESUs may exist within the Snake River Basin, the available data do not clearly demonstrate their existence or define their boundaries. Because of compelling genetic and life-history evidence that fall-run chinook salmon are distinct from other chinook salmon in the Snake River, however, they are considered a separate ESU.

Historically, spring/summer-run chinook salmon spawned in virtually all accessible and suitable habitat in the Snake River system (Evermann 1895; Fulton 1968). During the late 1800s, the Snake River produced a substantial fraction of all Columbia Basin spring and summer chinook salmon, with total production probably exceeding 1.5 million in some years. By the mid-1900s, the abundance of adult spring and summer chinook salmon had greatly declined. Fulton (1968) estimated that an average of 125,000 adults per year entered the Snake River tributaries from 1950 through 1960. As evidenced by adult counts at dams, however, spring and summer chinook salmon have declined considerably since the 1960s.

---

[1] Estimates of median population growth rate, risk of extinction, and the likelihood of meeting recovery goals presented here and below are based on population trends observed during a base period beginning in 1980. Population trends are projected under the assumption that all conditions will stay the same into the future. For further information, see, NMFS (2000).

In the Snake River, spring and summer chinook share key life history traits. Both are stream-type fish, with juveniles that migrate swiftly to sea as yearling smolts. Depending primarily on location within the basin (and not on run type), adults tend to return after either 2 or 3 years in the ocean. Both spawn and rear in small, high-elevation streams (Chapman *et al.* 1991), although where the two forms coexist, spring-run chinook spawn earlier and at higher elevations than summer-run chinook.

Even before mainstem dams were built, habitat was lost or severely damaged in small tributaries by construction and operation of irrigation dams and diversions, inundation of spawning areas by impoundments, and siltation and pollution from sewage, farming, logging, and mining (Fulton 1968). Recently, the construction of hydroelectric and water storage dams without adequate provision for adult and juvenile passage in the upper Snake River has kept fish from all spawning areas upstream of Hells Canyon Dam.

There is a long history of human efforts to enhance production of chinook salmon in the Snake River Basin through supplementation and stock transfers. The evidence is mixed as to whether these efforts have altered the genetic makeup of indigenous populations. Straying rates appear to be very low.

For the SR spring/summer-run chinook salmon ESU as a whole, NOAA Fisheries estimates that the median population growth rate (lambda) over the base period 1 ranges from 0.96 to 0.80, decreasing as the effectiveness of hatchery fish spawning in the wild increases compared to the effectiveness of fish of wild origin (Tables B-2a and B-2b in McClure *et al.* 2000b).

<u>LCR Chinook Salmon</u>
The lower Columbia River is characterized by numerous short- and medium-length rivers that drain the coast ranges and the west slope of the Cascade Mountains. The LCR chinook salmon ESU includes all native populations from the mouth of the Columbia River to the crest of the Cascade Range, excluding populations above Willamette Falls. The former location of Celilo Falls (inundated by The Dalles reservoir in 1960) is the eastern boundary for this ESU. Stream-type, spring-run chinook salmon found in the Klickitat River or the introduced Carson spring-run chinook salmon strain are not included in this ESU. Spring-run chinook salmon in the Sandy River have been influenced by spring-run chinook salmon introduced from the Willamette River ESU. However, analyses suggest that considerable genetic resources still reside in the existing population (Myers *et al.* 1998). Recent escapements above Marmot Dam on the Sandy River average 2,800 and have been increasing (ODFW 1998a). Tule fall chinook from the LCR chinook salmon ESU were observed spawning in the Ives Island area during October 1999. The Hardy/Hamilton Creeks/Ives Island complex is along the Washington shoreline approximately 2 miles below Bonneville Dam.

Historical records of chinook salmon abundance are sparse, but cannery records suggest a peak run of 4.6 million fish in 1883. Although fall-run chinook salmon are still present throughout much of their historical range, most of the fish spawning today are first-generation hatchery strays. Furthermore, spring-run populations have been severely depleted throughout the ESU and extirpated from several rivers.

Most fall-run fish in the LCR chinook salmon ESU emigrate to the marine environment as subyearlings (Reimers and Loeffel 1967, Howell *et al.* 1985, WDF *et al.* 1993). Returning adults that emigrated as yearling smolts may have originated from the extensive hatchery programs in the ESU. It is also possible that modifications in the river environment have altered the duration of freshwater residence. Coded-wire tag (CWT) recoveries of LCR chinook salmon fish suggest a northerly migration route, but (based on CWT recoveries) the fish contribute more to fisheries off British Columbia and Washington than to the Alaskan fishery. Tule fall chinook salmon return at adult ages 3 and 4; "bright" fall chinook return at ages 4 and 5, with significant numbers returning at age 6. Tule and bright chinook salmon are distinct in their spawn timing.

As in other ESUs, chinook salmon have been affected by the alteration of freshwater habitat (Bottom *et al.* 1984, WDF *et al.* 1993, Kostow 1995). Timber harvesting and associated road building peaked in the 1930s, but effects from the timber industry remain (Kostow 1995). Agriculture is widespread in this ESU and has affected riparian vegetation and stream hydrology. The ESU is also highly affected by urbanization, including river diking and channelization, wetland draining and filling, and pollution (Kostow 1995).

LCR chinook salmon has been subject to intensive hatchery influence. Hatchery programs to enhance chinook salmon fisheries in the lower Columbia River began in the 1870s, releasing billions of fish over time. That equals the total hatchery releases for all other chinook ESUs combined (Myers *et al.* 1998). Although most of the stocks have come from inside the ESU, more than 200 million fish from outside the ESU have been released since 1930 (Myers *et al.* 1998).

For the LCR chinook salmon ESU as a whole, NOAA Fisheries estimates that the median population growth rate (lambda) over the base period ranges from 0.98 to 0.88, decreasing as the effectiveness of hatchery fish spawning in the wild increases compared to that of fish of wild origin (Tables B-2a and B-2b in McClure *et al.* 2000b).

UWR Chinook Salmon

The UWR chinook salmon ESU includes native spring-run populations above Willamette Falls and in the Clackamas River. In the past, it included sizable numbers of spawning salmon in the Santiam River, the middle fork of the Willamette River, and the McKenzie River, as well as smaller numbers in the Molalla River, Calapooia River, and Albiqua Creek. Although the total number of fish returning to the Willamette has been relatively high (24,000), about 4,000 fish now spawn naturally in the ESU, two-thirds of which originate in hatcheries. The McKenzie River supports the only remaining naturally-reproducing population in the ESU (ODFW 1998a).

There are no direct estimates of the size of the chinook salmon runs in the Willamette Basin before the 1940s. McKernan and Mattson (1950) present anecdotal information that the Native American fishery at the Willamette Falls may have yielded 2,000,000 pounds (908,000 kg) of salmon (454,000 fish, each weighing 20 pounds [9.08 kg]). Based on egg collections at salmon hatcheries, Mattson (1948) estimates that the spring chinook salmon run in the 1920s may have been 5 times the run size of 55,000 fish in 1947, or 275,000 fish. Much of the early information on salmon runs in the upper Willamette River Basin comes from operation reports of state and Federal hatcheries.

Fish in this ESU are distinct from those of adjacent ESUs in life history and marine distribution. The life history of chinook salmon in the Upper Willamette River ESU includes traits from both ocean- and stream-type development strategies. CWT recoveries indicate that the fish travel to the marine waters off British Columbia and Alaska. However, more Willamette fish are recovered in Alaskan waters than fish from the Lower Columbia River ESU. UWR chinook salmon mature in their fourth or fifth years. Historically, 5-year-old fish dominated the spawning migration runs; recently, however, most fish have matured at age 4. The timing of the spawning migration is limited by Willamette Falls. High flows in the spring allow access to the upper Willamette basin, whereas low flows in the summer and autumn prevent later-migrating fish from ascending the falls. The low flows may serve as an isolating mechanism, separating this ESU from others nearby.

Human activities have had vast effects on the salmonid populations in the Willamette River drainage. First, the Willamette River, once a highly braided river system, has been dramatically simplified through channelization, dredging, and other activities that have reduced rearing habitat (*i.e.*, stream shoreline) by as much as 75%. In addition, the construction of 37 dams in the basin has blocked access to over 700 km of stream and river spawning habitat. The dams also alter the temperature regime of the Willamette and its tributaries, affecting the timing of development of naturally-spawned eggs and fry. Water quality is also affected by development and other economic activities. Agricultural and urban land uses on the valley floor, as well as timber harvesting in the Cascade and Coast ranges, contribute to increased erosion and sediment load in Willamette River Basin streams and rivers. Finally, since at least the 1920s, the lower Willamette River has suffered municipal and industrial pollution.

Hatchery production in the basin began in the late nineteenth century. Eggs were transported throughout the basin, resulting in current populations that are relatively homogeneous genetically (although still distinct from those of surrounding ESUs). Hatchery production continues in the Willamette River, with an average of 8.4 million smolts and fingerlings released each year into the main river or its tributaries between 1975 and 1994. Hatcheries are currently responsible for most production (90% of escapement) in the basin. The Clackamas River currently accounts for about 20% of the production potential in the Willamette Basin, originating from one hatchery plus natural production areas that are primarily above the North Fork Dam. The interim escapement goal for the area above North Fork Dam is 2,900 fish (ODFW 1998b). However, the system is so heavily influenced by hatchery production that it is difficult to distinguish spawners of natural stock from hatchery origin fish. Approximately 1,000 to 1,500 adults have been counted at the North Fork Dam in recent years.

Harvest on this ESU is high, both in the ocean and in river. The total in-river harvest below the falls from 1991 through 1995 averaged 33% and was much higher before then. Ocean harvest was estimated as 16% for 1982 through 1989. ODFW (1998a) indicates that total (marine and freshwater) harvest rates on UWR spring-run stocks were reduced considerably for the 1991 through 1993 brood years, to an average of 21%.

For the UWR chinook salmon ESU as a whole, NOAA Fisheries estimates that the median population growth rate (lambda) over the base period ranges from 1.01 to 0.63, decreasing as the effectiveness of hatchery fish spawning in the wild increases compared to that of fish of wild origin (Tables B-2a and B-2b in McClure *et al.* 2000b).

UCR Spring-Run Chinook Salmon

This ESU includes spring-run chinook populations found in Columbia River tributaries between Rock Island and Chief Joseph Dams, notably the Wenatchee, Entiat, and Methow River Basins. The populations are genetically and ecologically separate from the summer- and fall-run populations in the lower parts of many of the same river systems (Myers *et al.* 1998). Although fish in this ESU are genetically similar to spring chinook in adjacent ESUs (*i.e.*, mid-Columbia and Snake), they are distinguished by ecological differences in spawning and rearing habitat preferences. For example, spring-run chinook in upper Columbia River tributaries spawn at lower elevations (500 to 1,000 m) than in the Snake and John Day River systems.

The upper Columbia River populations were intermixed during the Grand Coulee Fish Maintenance Project (1939 through 1943), resulting in loss of genetic diversity between populations in the ESU. Homogenization remains an important feature of the ESU. Fish abundance has trended downward both recently and over the long term. At least six former populations from this ESU are now extinct, and nearly all extant populations have fewer than 100 wild spawners.

UCR spring-run chinook are considered stream-type fish, with smolts migrating as yearlings. Most stream-type fish mature at 4 years of age. Few CWTs are recovered in ocean fisheries, suggesting that the fish move quickly out of the north central Pacific and do not migrate along the coast.

Spawning and rearing habitat in the Columbia River and its tributaries upstream of the Yakima River includes dry areas where conditions are less conducive to steelhead survival than in many other parts of the Columbia Basin (Mullan *et al.* 1992). Salmon in this ESU must pass up to nine Federal and private dams, and Chief Joseph Dam prevents access to historical spawning grounds farther upstream. Degradation of remaining spawning and rearing habitat continues to be a major concern associated with urbanization, irrigation projects, and livestock grazing along riparian corridors. Overall harvest rates are low for this ESU, currently less than 10% (ODFW and WDFW 1995).

Spring-run chinook salmon from the Carson National Fish Hatchery (a large, composite, non-native stock) were introduced into, and have been released from, local hatcheries (Leavenworth, Entiat, and Winthrop National Fish Hatcheries [NFH]). Little evidence suggests that these hatchery fish stray into wild areas or hybridize with naturally-spawning populations. In addition to these national production hatcheries, two supplementation hatcheries are operated by the WDFW in this ESU. The Methow Fish Hatchery Complex (operations began in 1992) and the Rock Island Fish Hatchery Complex (operations began in 1989) were both designed to implement supplementation programs for naturally spawning populations on the Methow and Wenatchee Rivers, respectively (Chapman *et al.* 1995).

For the UCR spring-run chinook salmon ESU as a whole, NOAA Fisheries estimates that the median population growth rate (lambda) over the base period ranges from 0.85 to 0.83, decreasing as the effectiveness of hatchery fish spawning in the wild increases compared to that of fish of wild origin (Tables B-2a and B-2b in McClure *et al.* 2000b). NOAA Fisheries used population risk assessments for UCR spring-run chinook salmon and steelhead ESUs from the draft quantitative analysis report (QAR) (Cooney 2000). Risk assessments described in that report were based on Monte Carlo simulations with simple spawner/spawner models that incorporate estimated smolt carrying capacity. Population dynamics were simulated for three separate spawning populations in the UCR spring-run chinook salmon ESU, the Wenatchee, Entiat, and Methow populations. The QAR assessments showed extinction risks for UCR spring chinook salmon of 50% for the Methow, 98% for the Wenatchee, and 99% for the Entiat spawning populations. These estimates are based on the assumption that the median return rate for the 1980 brood year to the 1994 brood year series will continue into the future.

<u>CR Chum Salmon</u>
Chum salmon of the Columbia River ESU spawn in tributaries and in mainstem areas below Bonneville Dam. Most fish spawn on the Washington side of the Columbia River (Johnson *et al.* 1997). Previously, chum salmon were reported in almost every river in the lower Columbia River Basin, but most runs disappeared by the 1950s (Rich 1942, Marr 1943). Currently, WDFW regularly monitors only a few natural populations in the basin: one in Grays River, two in small streams near Bonneville Dam, and the mainstem area next to one of the latter two streams. Recently, spawning has occurred in the mainstem Columbia River at two spots near Vancouver, Washington, and in Duncan Creek below Bonneville Dam.

Chum salmon enter the Columbia River from mid-October through early December and spawn from early November to late December. Recent genetic analysis of fish from Hardy and Hamilton Creeks and from the Grays River indicate that these fish are genetically distinct from other chum salmon populations in Washington. Genetic variability within and between populations in several geographic areas is similar, and populations in Washington show levels of genetic subdivision typical of those seen between summer- and fall-run populations in other areas and typical of populations within run types (Salo 1991, WDF *et al.* 1993, Phelps *et al.* 1994, and Johnson *et al.* 1997).

Historically, the CR chum salmon ESU supported a large commercial fishery, landing more than 500,000 fish per year. Commercial catches declined beginning in the mid-1950s. There are now no recreational or directed commercial fisheries for chum salmon in the Columbia River, although chum salmon are taken incidentally in the gill-net fisheries for coho and chinook salmon, and some tributaries have a minor recreational harvest (WDF *et al.* 1993).

Hatchery fish have had little influence on the wild component of the CR chum salmon ESU. NOAA Fisheries estimates an median population growth rate (lambda) over the base period, for the ESU as a whole, of 1.04 (Tables B-2a and B-2b in McClure *et al.* 2000b). Because census data are peak counts (and because the precision of those counts decreases markedly during the spawning season as water levels and turbidity rise), NOAA Fisheries is unable to estimate the risk of absolute extinction for this ESU.

<u>SR Sockeye Salmon</u>
The only remaining anadromous sockeye in the Snake River system are found in Redfish Lake, on the Salmon River. The nonanadromous form (kokanee), found in Redfish Lake and elsewhere in the Snake River Basin, is included in the ESU. SR sockeye were historically abundant in several lake systems of Idaho and Oregon. However, all populations have been extirpated in the past century, except fish returning to Redfish Lake.

In general, juvenile sockeye salmon rear in the lake environment for 1, 2, or 3 years before migrating to sea. Adults typically return to the natal lake system to spawn after spending 1, 2, 3, or 4 years in the ocean (Gustafson *et al.* 1997).

In 1910, impassable Sunbeam Dam was constructed 20 miles downstream of Redfish Lake. Although several fish ladders and a diversion tunnel were installed during subsequent decades, it is unclear whether enough fish passed above the dam to sustain the run. The dam was partly removed in 1934, after which Redfish Lake runs partially rebounded. Evidence is mixed as to whether the restored runs constitute anadromous forms that managed to persist during the dam years, nonanadromous forms that became migratory, or fish that strayed in from outside the ESU.

NOAA Fisheries proposed an interim recovery level of 2,000 adult SR sockeye salmon in Redfish Lake and two other lakes in the Snake Basin (Table 1.3-1 in NMFS 1995). Low numbers of adult SR sockeye salmon preclude a QAR-type quantitative analysis of the status of this ESU. Because only 16 wild and 264 hatchery-produced adult sockeye returned to the Stanley River Basin between 1990 and 2000, however, NOAA Fisheries considers the status of this ESU to be dire under any criteria. Clearly, the risk of extinction is very high.

<u>UCR steelhead</u>
The UCR steelhead ESU occupies the Columbia Basin upstream of the Yakima River. Rivers in the area primarily drain the east slope of the northern Cascade Mountains and include the Wenatchee, Entiat, Methow, and Okanogan River basins. The climate of the area reaches temperature and precipitation extremes; most precipitation falls as mountain snow. The river valleys are deeply dissected and maintain low gradients, except for the extreme headwaters (Franklin and Dyrness 1973).

Estimates of historical (pre-1960s) abundance specific to this ESU are available from fish counts at dams. Counts at Rock Island Dam from 1933 to 1959 averaged 2,600 to 3,700, suggesting a prefishery run size exceeding 5,000 adults for tributaries above Rock Island Dam (Chapman *et al.* 1994). However, runs may already have been depressed by lower Columbia River fisheries.

As in other inland ESUs (the Snake and mid-Columbia Basins), steelhead in the Upper Columbia River ESU remain in freshwater up to a year before spawning. Smolt age is dominated by 2-year-olds. Based on limited data, steelhead from the Wenatchee and Entiat rivers return to freshwater after 1 year in salt water, whereas Methow River steelhead are primarily age-2-ocean (Howell *et al.* 1985). Life history characteristics for UCR steelhead are similar to those of other inland steelhead ESUs; however, some of the oldest smolt ages for steelhead, up to 7 years, are reported from this ESU. The relationship between anadromous and nonanadromous forms in the geographic area is unclear.

The Chief Joseph and Grand Coulee Dam construction caused blockages of substantial habitat, as did that of smaller dams on tributary rivers. Habitat issues for this ESU relate mostly to irrigation diversions and hydroelectric dams, as well as to degraded riparian and instream habitat from urbanization and livestock grazing.

Hatchery fish are widespread and escape to spawn naturally throughout the region. Spawning escapement is dominated by hatchery-produced fish.

For the UCR steelhead ESU as a whole, NOAA Fisheries estimates that the median population growth rate (lambda) over the base period ranges from 0.94 to 0.66, decreasing as the effectiveness of hatchery fish spawning in the wild increases compared to that of fish of wild origin (Tables B-2a and B-2b in McClure *et al.* 2000b). Because of data limitations, the QAR steelhead assessments in Cooney (2000) were limited to two aggregate spawning groups—the Wenatchee/Entiat composite and the above-Wells populations. Wild production of steelhead above Wells Dam was assumed to be limited to the Methow system. Assuming a relative effectiveness of hatchery spawners of 1.0, the risk of absolute extinction within 100 years for UCR steelhead is 100%. The QAR also assumed hatchery effectiveness values of 0.25 and 0.75. A hatchery effectiveness of 0.25 resulted in projected risks of extinction of 35% for the Wenatchee/Entiat and 28% for the Methow populations. At a hatchery effectiveness of 0.75, risks of 100% were projected for both populations.

<u>SR Basin Steelhead</u>
Steelhead spawning habitat in the Snake River is distinctive in having large areas of open, low-relief streams at high elevations. In many Snake River tributaries, spawning occurs at a higher elevation (up to 2,000 m) than for steelhead in any other geographic region. SR Basin steelhead also migrate farther from the ocean (up to 1,500 km) than most.

No estimates of historical (pre-1960s) abundance specific to this ESU are available.

Fish in this ESU are summer-run steelhead. They enter freshwater from June to October and spawn during the following March to May. Two groups are identified, based on migration timing, ocean-age, and adult size. A-run steelhead, thought to be predominately age-1-ocean, enter freshwater during June through August. B-run steelhead, thought to be age-2-ocean, enter freshwater during August through October. B-run steelhead typically are three to four inches longer at the same age. Both groups usually smolt as 2- or 3-year-olds (Whitt 1954, Hassemer 1992). All steelhead are iteroparous, capable of spawning more than once before death.

Hydrosystem projects create substantial habitat blockages in this ESU; the major ones are the Hells Canyon Dam complex (mainstem Snake River) and Dworshak Dam (North Fork Clearwater River). Minor blockages are common throughout the region. Steelhead spawning areas have been degraded by overgrazing, as well as by historical gold dredging and sedimentation due to poor land management. Habitat in the Snake River Basin is warmer and drier and often more eroded than elsewhere in the Columbia Basin or in coastal areas.

Hatchery fish are widespread and stray to spawn naturally throughout the region. In the 1990s, an average of 86% of adult steelhead passing Lower Granite Dam were of hatchery origin. Hatchery contribution to naturally spawning populations varies, however, across the region. Hatchery fish dominate some stocks, but do not contribute to others.

For the SR Basin steelhead ESU as a whole, NOAA Fisheries estimates that the median population growth rate (lambda) over the base period ranges from 0.91 to 0.70, decreasing as the effectiveness of hatchery fish spawning in the wild increases compared to that of fish of wild origin (Tables B-2a and B-2b in McClure *et al.* 2000b).

<u>LCR Steelhead</u>

The Lower Columbia River ESU encompasses all steelhead runs in tributaries between the Cowlitz and Wind Rivers on the Washington side of the Columbia River, and the Willamette and Hood Rivers on the Oregon side. The populations of steelhead that make up the Lower Columbia River ESU are distinguished from adjacent populations by genetic and habitat characteristics. The ESU consists of summer and winter coastal steelhead runs in the tributaries of the Columbia River as it cuts through the Cascades. These populations are genetically distinct from inland populations (east of the Cascades), as well as from steelhead populations in the upper Willamette River Basin and coastal runs north and south of the Columbia River mouth. Not included in the ESU are runs in the Willamette River above Willamette Falls (Upper Willamette River ESU), runs in the Little and Big White Salmon rivers (Middle Columbia River ESU) and runs based on four imported hatchery stocks: early-spawning winter Chambers Creek/lower Columbia River mix, summer Skamania Hatchery stock, winter Eagle Creek NFH stock, and winter Clackamas River ODFW stock (63 FR 13351 and 13352). This area has at least 36 distinct runs (Busby *et al.* 1996), 20 of which were identified in the initial listing petition. In addition, numerous small tributaries have historical reports of fish, but no current abundance data. The major runs in the ESU, for which there are estimates of run size, are the Cowlitz River winter runs, Toutle River winter runs, Kalama River winter and summer runs, Lewis River winter and summer runs, Washougal River winter and summer runs, Wind River summer runs, Clackamas River winter and summer runs, Sandy River winter and summer runs, and Hood River winter and summer runs.

For the larger runs, current counts have been in the range of one to 2,000 fish (Cowlitz, Kalama, and Sandy Rivers); historical counts, however, put these runs at more than 20,000 fish. In general, all runs in the ESU have declined over the past 20 years, with sharp declines in the last five years.

Steelhead in this ESU are thought to use estuarine habitats extensively during out migration, smoltification, and spawning migrations. The lower reaches of the Columbia River are highly modified by urbanization and dredging for navigation. The upland areas covered by this ESU are extensively logged, affecting water quality in the smaller streams used primarily by summer runs. In addition, all major tributaries used by LCR steelhead have some form of hydraulic barrier that impedes fish passage. Barriers range from impassible structures in the Sandy Basin that block access to extensive, historically occupied, steelhead habitat, to passable but disruptive projects on the Cowlitz and Lewis Rivers. The Biological Review Team (BRT 1997) viewed the overall effect of hydrosystem activities on this ESU as an important determinant of extinction risk.

Many populations of steelhead in the Lower Columbia River ESU are dominated by hatchery escapement. Roughly 500,000 hatchery-raised steelhead are released into drainages within this ESU each year. As a result, first-generation hatchery fish are thought to make up 50% to 80% of the fish counted on natural spawning grounds. The effect of hatchery fish is not uniform, however. Several runs are mostly hatchery strays (*e.g.*, the winter run in the Cowlitz River [92%] and the Kalama River [77%] and the summer run in the North Fork Washougal River [50%]), whereas others are almost free of hatchery influence (the summer run in the mainstem Washougal River [0%] and the winter runs in the North Fork Toutle and Wind Rivers [0 to 1%]).

Escapement estimates for the steelhead fishery in the Lower Columbia River ESU are based on in river and estuary sport-fishing reports; there is a limited ocean fishery on this ESU. Harvest rates range from 20 to 50% on the total run, but for hatchery-wild differentiated stocks, harvest rates on wild fish have dropped to 0 to 4% in recent years (punch card data from WDFW through 1994).

For the LCR steelhead ESU as a whole, NOAA Fisheries estimates that the median population growth rate (lambda) over the base period ranges from 0.98 to 0.78, decreasing as the effectiveness of hatchery fish spawning in the wild increases compared to that of fish of wild origin (Tables B-2a and B-2b in McClure *et al.* 2000b).

<u>UWR Steelhead</u>

The UWR steelhead ESU occupies the Willamette River and tributaries upstream of Willamette Falls, extending to and including the Calapooia River. These major river basins containing spawning and rearing habitat comprise more than 12,000 km^2 in Oregon. Rivers that contain naturally spawning winter-run steelhead include the Tualatin, Molalla, Santiam, Calapooia, Yamhill, Rickreall, Luckiamute, and Mary's, although the origin and distribution of steelhead in a number of these basins is being debated. Early migrating winter and summer steelhead have been introduced into the upper Willamette Basin, but those components are not part of the ESU. Native winter steelhead within this ESU have been declining since 1971, and have exhibited large fluctuations in abundance.

In general, native steelhead of the upper Willamette Basin are late-migrating winter steelhead, entering freshwater primarily in March and April. This atypical run timing appears to be an adaptation for ascending Willamette Falls, which functions as an isolating mechanism for UWR steelhead. Reproductive isolation resulting from the falls may explain the genetic distinction between steelhead from the upper Willamette Basin and those in the lower river. UWR late-migrating steelhead are ocean-maturing fish. Most return at age 4, with a small proportion returning as 5-year-olds (Busby *et al.* 1996).

Willamette Falls (Rkm 77) is a known migration barrier. Winter steelhead and spring chinook salmon historically occurred above the falls, whereas summer steelhead, fall chinook, and coho salmon did not. Detroit and Big Cliff Dams cut off 540 km of spawning and rearing habitat in the North Santiam River. In general, habitat in this ESU has become substantially simplified since the 1800s by removal of large woody debris to increase the river's navigability.

The main hatchery production of native (late-run) winter steelhead occurs in the North Fork Santiam River, where estimates of hatchery proportion in natural spawning areas range from 14 to 54% (Busby *et al.* 1996). More recent estimates of the percentage of naturally-spawning fish attributable to hatcheries in the late 1990s are 24% in the Molalla, 17% in the North Santiam, 5 to 12% in the South Santiam, and less than 5% in the Calapooia (Chilcote 1997).

For the UWR steelhead ESU as a whole, NOAA Fisheries estimates that the median population growth rate (lambda) over the base period ranges from 0.94 to 0.87, decreasing as the effectiveness of hatchery fish spawning in the wild increases compared to that of fish of wild origin (Tables B-2a and B-2b in McClure *et al.* 2000b).

<u>MCR Steelhead</u>
The MCR steelhead ESU occupies the Columbia River Basin from above the Wind River in Washington and the Hood River in Oregon and continues upstream to include the Yakima River, Washington. The region includes some of the driest areas of the Pacific Northwest, generally receiving less than 16 inches of precipitation annually (Jackson 1993). Summer steelhead are widespread throughout the ESU; winter steelhead occur in Mosier, Chenowith, Mill, and Fifteenmile creeks, Oregon, and in the Klickitat and White Salmon Rivers, Washington. The John Day River probably represents the largest native, naturally-spawning stock of steelhead in the region.

Estimates of historical (pre-1960s) abundance specific to this ESU are available for the Yakima River, which has an estimated run size of 100,000 (WDF *et al.* 1993). Assuming comparable run sizes for other drainage areas in this ESU, the total historical run size may have exceeded 300,000 steelhead.

Most fish in this ESU smolt at 2 years and spend 1 to 2 years in salt water before reentering freshwater, where they may remain up to a year before spawning (Howell *et al.* 1985). All steelhead upstream of The Dalles Dam are summer-run (Chapman *et al.* 1994). The Klickitat River, however, produces both summer and winter steelhead, and age-2-ocean steelhead dominate the summer steelhead, whereas most other rivers in the region produce about equal numbers of both age-1- and 2-ocean fish. A nonanadromous form co-occurs with the anadromous form in this ESU; information suggests that the two forms may not be isolated reproductively, except where barriers are involved.

The only substantial habitat blockage now present in this ESU is at Pelton Dam on the Deschutes River, but minor blockages occur throughout the region. Water withdrawals and overgrazing have seriously reduced summer flows in the principal summer steelhead spawning and rearing tributaries of the Deschutes River. This is significant because high summer and low winter temperatures are limiting factors for salmonids in many streams in this region (Bottom *et al.* 1984).

Continued increases in the proportion of stray steelhead in the Deschutes Basin is a major concern. The ODFW and the Confederated Tribes of the Warm Springs Reservation of Oregon (CTWSRO) estimate that 60 to 80% of the naturally-spawning population consists of strays, which greatly outnumber naturally-produced fish. Although the reproductive success of stray fish has not been evaluated, their numbers are so high that major genetic and ecological effects on natural populations are possible (Busby *et al.* 1999). The negative effects of any interbreeding between stray and native steelhead will be exacerbated if the stray steelhead originated in geographically distant river basins, especially if the river basins are in different ESUs. The populations of steelhead in the Deschutes Basin include steelhead native to the Deschutes River, hatchery steelhead from the Round Butte Hatchery on the Deschutes River, wild steelhead strays from other rivers in the Columbia Basin, and hatchery steelhead strays from other Columbia Basin streams

Regarding the latter, CTWSRO reports preliminary findings from a tagging study by T. Bjornn and M. Jepson (University of Idaho) and NOAA Fisheries suggesting that a large fraction of the steelhead passing through Columbia River dams (*e.g.*, John Day and Lower Granite dams) have entered the Deschutes River and then returned to the mainstem Columbia River. A key unresolved question about the large number of strays in the Deschutes basin is how many stray fish remain in the basin and spawn naturally.

For the MCR steelhead ESU as a whole, NOAA Fisheries estimates that the median population growth rate (lambda) over the base period10 ranges from 0.88 to 0.75, decreasing as the effectiveness of hatchery fish spawning in the wild increases compared to that of fish of wild origin (Tables B-2a and B-2b in McClure *et al.* 2000b).

The relevant biological requirements are those necessary for the listed species to survive and recover to a naturally-reproducing population level, at which time protection under the ESA would become unnecessary. Adequate population levels must safeguard the genetic diversity of the listed stock, enhance its capacity to adapt to various environmental conditions, and allow it to become self-sustaining in the natural environment.

For this consultation, the biological requirements are improved habitat characteristics that function to support successful rearing and migration. The status of the listed species, based upon their risk of extinction, has not significantly improved since the species were listed.

1.4.2 Environmental Baseline

Regulations implementing section 7 of the Act (50 C.F.R. 402.02) define the environmental baseline as the past and present impacts of all Federal, state, or private actions and other human activities in the action area. The environmental baseline also includes the anticipated impacts of all proposed Federal projects in the action area that have undergone section 7 consultation, and the impacts of state and private actions that are contemporaneous with the consultation in progress. The action area is defined in 50 CFR 402.02 to mean "all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action." The direct effects occur at the project site and may extend upstream or downstream, based on the potential for impairing fish passage, hydraulics, sediment and pollutant discharge, and the extent of riparian habitat modifications. Indirect effects may occur throughout the watershed where actions described in this Opinion lead to additional activities or affect ecological functions contributing to stream degradation.

The environmental baseline represents the set of conditions to which the effects of the proposed or continuing action are added. It includes “the past and present impacts of all Federal state or private activities in the action area, the anticipated impacts of all proposed Federal projects in the action that have already undergone formal or early section 7 consultation and the impact of state or private actions which are contemporaneous with the consultation in process (50 CFR 402.02 [1999]).” The environmental baseline does not include any future discretionary Federal activities in the action area that have not yet undergone ESA consultation in the action area. The species’ current status is described in relation to the risks presented by the continuing effects of all previous actions and resource commitments that are not subject to further exercise of Federal discretion. For an ongoing Federal action, those effects of the action resulting from past unalterable resource commitments are included in the baseline, and those effects that would be caused by the continuing of the proposed action are then analyzed for determination of effects. The reason for determining the species’ status under the environmental baseline is to better understand the relative significance of the effects of the proposed action upon the species likelihood of survival and chances for recovery. Thus, if the species status is poor and the baseline is degraded at the time of consultation, it is more likely that any additional adverse effects caused by the proposed or continuing action will be significant.

Biological requirements of the listed species are currently not being met under the environmental baseline. A significant improvement in the environmental conditions they experience over those currently available under the environmental baseline is needed. Any further degradation of these conditions would have a significant impact due to the amount of risk they presently face under the environmental baseline.

The Columbia River is naturally a very dynamic system. It has been affected and shaped over eons by a variety of natural forces, including volcanic activity, storms, floods, natural events, and climatological changes. These forces had, and continue to have, a significant influence on biological factors, habitat, inhabitants, and the whole riverine and estuarine environment of the Columbia River. Over the past century, human activities have dampened the range of physical forces in the action area and resulted in extensive changes in the Lower Columbia River and estuary. To a significant degree, the risk of extinction for salmon stocks in the Columbia River basin has increased because complex freshwater and estuarine habitats needed to maintain diverse wild populations and life histories have been lost and fragmented. Not only have rearing habitats been removed, but the connections among habitats needed to support tidal and seasonal movements of juvenile salmon have been severed. The Lower Columbia River estuary has lost approximately 43% of its historic tidal marsh (from 16,180 to 9,200 acres) and 77% of historic tidal swamp habitats (from 32,020 to 6,950 acres) between 1870 and 1970 (Thomas 1983). One example is the diking and filling of floodplains formerly connected to the tidal river, which have resulted in the loss of large expanses of low-energy, off-channel habitat for salmon rearing and migrating during high flows. Similarly, diking of estuarine marshes and forested wetlands within the estuary have removed most of these important off-channel habitats. Sherwood *et al.* (1990) estimated that the Columbia River estuary lost 20,000 acres of tidal swamps, 10,000 acres of tidal marshes, and 3,000 acres of tidal flats between 1870 and 1970. This study further estimated an 80% reduction in emergent vegetation production and a 15% decline in benthic algal production.

Within the Lower Columbia River, diking, river training devices (pile dikes and riprap), railroads, and highways have narrowed and confined the river to its present location. Between the Willamette River and the mouth of the Columbia River, diking, flow regulation, and other human activities have resulted in a confinement of 84,000 acres of flood plain that likely contained large amounts of tidal marsh and swamp. The Lower Columbia River's remaining tidal marsh and swamp habitats are in a narrow band along the Columbia River and tributaries' banks and around undeveloped islands.

Since the late 1800s, the COE has been responsible for maintaining navigation safety on the Columbia River. To improve navigation and reduce maintenance dredging, the navigation channel has also been realigned and hydraulic control structures, such as in-water fills, channel constrictions, and pile dikes, have been built. Most of the present-day pile dike system was built during the periods of 1917 to 1923, and 1933 to 1939, with an additional 35 pile dikes constructed between 1957 and 1967. The existing navigation channel pile dike system consists of 256 pile dikes, totaling 240,000 linear feet. Ogden Beeman and Associates (1985) termed these COE activities "river regulation", and noted that navigation channel maintenance activities, for a 100-year period prior to their 1985 report, required closing of river side channels, realigning river banks, removing rock sills, stabilizing river banks, and placement of river "training" features. Most of these baseline river training features and habitat alterations were constructed or occurred before any of the current ESA-listed salmonids were placed on the list of endangered and threatened species.

Flow regulation, water withdrawal and climate change have reduced the Columbia River's average flow and altered the seasonality of Columbia River flows, sediment discharge and turbidity, which have changed the estuarine ecosystem (National Research Council, 1996; Sherwood *et al.*, 1990; Simenstad *et al.*, 1990, Weitkamp, 1994). Annual spring freshet flows through the Columbia River estuary are approximately one-half of the traditional levels that flushed the estuary and carried smolts to sea, and total sediment discharge is approximately one-third of 19th century levels. For instance, flow regulation that began in the 1970s has reduced the 2-year flood peak discharge, as measured at The Dalles, Oregon, from 580,000 cubic feet per second (cfs) to 360,000 cfs (Corps 1999). Decreased spring flows and sediment discharges have also reduced the extent, speed of movement, thickness, and turbidity of the plume that extended far out and south into the Pacific Ocean during the spring and summer (Cudaback and Jay, 1996; Hickey *et al.*, 1997).

Changes in estuarine bathymetry and flow have altered the extent and pattern of salinity intrusion into the river and have increased stratification and reduced mixing (Sherwood *et al.*, 1990).
These aforementioned physical changes also affect other factors in the riverine and estuarine environment. Tides raise and lower river levels at least 4 feet and up to 12 feet twice every day. The historical range for tides was probably similar, but seasonal ranges and extremes in water surface elevations have certainly changed because of river flow regulation. The salinity level in areas of the estuary can vary from zero to 34 parts per 37 thousand (ppt) depending on tidal intrusion, river flows, and storms. Flow regulation has affected the upstream limit of salinity intrusion. The salinity wedge is believed to have ranged from the river mouth to as far upstream as RM 37.5 in the past. It is now generally believed that the salinity intrusion ranges between the mouth and RM 30. The river bed within the navigation channel is composed of a continuously moving series of sand waves that can migrate up to 20 feet per day at flows of 400,000 cfs or greater, and at slower rates at lesser flows. This rate of river discharge is not experienced as often as it was prior to flow regulation in the Columbia River. Although the Columbia River is characterized as a highly energetic system, it has been changing as a result of development and is now similar to more developed and less energetic estuaries throughout the world (Sherwood, *et al.*, 1990).

Water quality is another important aspect of the environmental condition of the Lower Columbia River and ecosystem with the potential to affect salmonid's growth and survival. The uptake of toxicants during juvenile salmonid residence in the Lower Columbia River and estuary (NWFSC Environmental Conservation Division 2001) can affect their growth and survival. In field studies, juvenile salmon from sites in the Pacific Northwest show demonstrable effects, including immunosuppression, reduced disease resistance, and reduced growth rates, due to contaminant exposure during their estuarine residence (Arkoosh *et al.* 1991, 1994, 1998; Varanasi *et al.* 1993; Casillas *et al.* 1995a,b, 1998). Current environmental conditions in the Columbia River estuary indicate the presence of contaminants in the food chain of juvenile salmonids. Fish from a site near Sand Island, in the mouth of the Columbia River, had whole body concentrations of dichlorodiphenyl trichloroethane (DDT) and polychlorinated biphenyls (PCB) were 44 ng/g wet wt (~ 220 ng/g dry wt) and 53 ng/g wet wt (~ 265 ng/g dry wt), respectively (NWFSC Environmental Conservation Division 2001. The findings of elevated levels of DDTs and PCBs in stomach contents of fish from Sand Island, however, is clear evidence that fish are being exposed to these contaminants while they are in the estuary. Levels of DDTs in stomach contents were 52 ng/g wet weight, and levels of PCBs were 33 ng/g wet weight. Although the Sand Island samples were collected from a mixed population of hatchery and wild fish and it is likely that DDTs and PCBs in hatchery food make some contribution to contaminant body burdens, the values seen were among the highest levels measured at estuarine sites in Washington and Oregon. By comparison, in the Duwamish estuary, a heavily contaminated industrial estuary near Seattle, mean whole body DDT levels in juvenile chinook salmon were 25 ng/g wet wt (~125 ng/g dry wt) and whole body PCB levels were 68 ng/g wet wt (~340 ng/g dry wt) (NWFSC Environmental Conservation Division 2001).

More recently, additional samples were analyzed from salmon collections in 1999 and 2000 (NWFSC Environmental Conservation Division, 2001). These analyses show that concentrations of PCBs and DDTs are consistently elevated in chinook salmon collected from Sand Island in the mouth of the Columbia River. Measured concentrations of DDTs in salmon bodies ranged from 32 to 56 ng/g dry wt, and concentrations of 38 PCBs ranged from 23 to 160 ng/g dry wt (NWFSC Environmental Conservation Division 2001, Fig. 8). No significant differences in mean concentrations of either of these contaminants were found over the three years during which fish were sampled. Elevated levels of PCBs and DDTs were also consistently found in stomach contents of sampled fish, indicating that juvenile salmon caught near Sand Island are taking these contaminants up in their diet. The concentrations of PCBs present in Sand Island fish are a cause for concern, because they are approaching or even exceeding estimated threshold tissue concentrations for adverse effects in salmonids (Meador, 2000). These values range from 120-360 ng/g dry wt for fish with total body lipid concentrations of 1 to 3%, which are typical of juvenile salmon collected within Pacific Northwest estuaries. At an average of 265 ng/g dry wt, PCB concentrations in Sand Island fish are well within the range of the effects threshold.

Available data suggest that exposure to polyaromatic hydrocarbons (PAH) may be quite variable in juvenile salmon from the Lower Columbia River. In stomach contents of juvenile chinook salmon collected near Sand Island in 1998, PAH concentrations were barely detectable, below levels seen in salmon from moderately developed estuaries such as Yaquina Bay and Grays Harbor, and well below levels found in stomach contents of salmon from industrialized waterways of Puget Sound (*e.g.*, Hylebos Waterway) (NWFSC Environmental Conservation Division 2001, Fig. 9). Similarly, concentrations of PAH metabolites in bile were relatively low in juvenile salmon from Sand Island in comparison to fish from urban Puget Sound sites (e.g., the Duwamish and Hylebos Waterways) (NWFSC Environmental Conservation Division 2001,

Fig. 10). Juvenile salmon sampled near Sand Island in 2000, however, showed somewhat greater exposure to PAHs than salmon sampled in 1998. Concentrations of PAHs and their metabolites in both stomach contents and fish bile were considerably higher in 2000 than in 1998 (NWFSC Environmental Conservation Division 2001). Concentrations were still lower than those observed in fish from urban estuaries in Puget Sound, but were comparable to those observed in fish from moderately development estuaries along the Washington and Oregon coast, such as Yaquina Bay or Coos Bay.

These data indicate that juvenile salmonids within the Columbia River estuary have contaminant body burdens that may already be within the range where sublethal effects may occur, although the sources of exposure are not clear.

All ESA-listed salmonids must pass through the Lower Columbia River, estuary and river mouth twice: once as juveniles en route to the Pacific Ocean and again as adults when they return to spawn. The Lower Columbia River and estuary serve three primary roles for outmigrating juveniles as they transition from shallow freshwater environments to the ocean possible: (1) A place where juvenile fish can gradually acclimate to salt water; (2) a feeding area (*i.e.*, main, and tidal channel, unvegetated shoals, emergent and forested wetlands, and mudflats) capable of sustaining increased growth rates; and (3) a refuge from predators while fish acclimate to salt water.

Thus, though the Lower Columbia River is important to the survival and recovery of all ESA-listed salmonids, it is particularly important to ocean-type salmon. These stocks may be particularly sensitive to ecosystem changes because of their longer residence times and dependence on this portion of the river for growth and survival.

Ocean-type salmon ESUs in the Columbia River include chinook ESUs (Lower Columbia River, SR fall, and Upper Willamette River) and Columbia River chum salmon ESUs. These ESUs are the most likely to be affected by potential impacts of the project, and thus are discussed in detail below.

Ocean-type subyearlings migrate through the action area during their downstream migration. Because of this, many spend some time rearing within the riverine reach, however, there is considerable variability in the freshwater rearing period of subyearling populations. Some subyearlings spawned in the lower reaches of coastal tributaries migrate almost immediately to marine areas following emergence from the gravel. Other subyearlings rear in freshwater for weeks to months, particularly those spawned well upstream in larger river systems such as the Columbia. The migration rate for subyearlings undergoing the rearing migration through the riverine reach is likely to be a few to 10 km per day. Subyearlings migrating directly to the estuary migrate at rates of 15 to 30 km per day (MacDonald, 1960; Simenstad, *et al.*, 1982; MacDonald, *et al.*, 1987; Murphy, *et al.*, 1989; Fisher and Pearcy, 1990).

Young salmonids must undergo a physiological transition and develop enough strength, energy, and reserve capacity to adapt to and survive the physical and biological challenges of the ocean environment, as well as to successfully obtain prey in that environment. Juvenile salmonids appear to reach the threshold for this transitional state at a size of 70 to 100 millimeters (mm). Before fish reach this size, their ocean survival would be difficult. The first outbound migrants of the Lower Columbia River fall chinook and chum may arrive in the action area as early as late February (Herrmann, 1970; Craddock, *et al.*, 1976; Healey, 1980; Congleton, *et al.*, 1981; Healey, 1982; Dawley, *et al.*, 1986; Levings, *et al.*, 1986). The majority of these fish are present from March through June. Outbound SR fall-run chinook begin their migration much farther upstream and arrive in the Lower Columbia River approximately a month later.

Ocean-type subyearlings arrive in the action area at a small size. The earliest migrants can be as small as 30 to 40 mm fork length (*i.e.*, from snout to fork in the tail) when they arrive because some of these fish hatch only a short distance upstream from the action area. Later spring migrants are generally larger, ranging up to 50 to 80 mm. Subyearlings from the mid-Columbia and Snake Rivers tend to be substantially larger (70 to 100 mm) by the time they reach the Lower Columbia River. The larger size of the Lower SR fall-run chinook, compared with the Lower Columbia River chinook and chum, likely indicates some differences in suitable habitat. The larger subyearlings from the Snake River can likely use a greater range of depth and current conditions than the subyearlings of the Lower Columbia River ESUs can.

Once ocean-type subyearlings arrive in the Lower Columbia River, they may remain for weeks to months. Because these fish arrive small in size, they undergo extended lower river and estuary rearing before they reach the transitional size necessary to migrate into the ocean (70 to 100 mm). This larger size is necessary to deal with the physical conditions and predators they face in the ocean environment, as well as to be successful in obtaining prey in that environment. At growth rates of about 0.3 to 1 mm per day (Levy, *et al.*, 1979; Argue *et al.*, 1985; Fisher and Pearcy, 1990), the subyearlings require weeks to months to reach this larger size. During this time, young chinook increase by about 5 to 8 grams per day or approximately 6% of their body weight (Herrmann, 1970; Healey, 1980).

Subyearlings are commonly found within a few meters of the shoreline at water depths of less than 1 meter. Although they migrate between areas over deeper water, they generally remain close to the water surface and near the shoreline during rearing, favoring water no more than 2 meters deep and areas where currents do not exceed 0.3 meter per second. They seek lower energy areas where waves and currents do not require them to expend considerable energy to remain in position while they consume invertebrates that live on or near the substrate. These areas are characterized by relatively fine grain substrates. However, it is not uncommon to find young salmonids in areas with steeper and harder substrates, such as sand and gravel.

Adult salmon returning to the Columbia River migrate through the river mouth throughout the year. The majority move through this area from early spring through autumn. A number of physical characteristics in the riverine reach affect the quality and quantity of habitat available for salmonids. These include the availability of prey, temperature, turbidity, and suspended solids.

Young chinook in the Lower Columbia River consume a variety of prey—primarily insects in the spring and fall and *Daphnia* from July to October (Craddock, *et al.*, 1976). *Daphnia* are the major prey during the summer and fall months, selected more than other planktonic organisms. Young salmonids consume *diptera, hymenoptera, coleoptera, tricoptera*, and *ephemeroptera* in the area just upstream from the estuary (Dawley, *et al.*, 1986). Bottom and Jones (1990) recently reported that young chinook ate primarily *Corophium, Daphnia*, and insects, with *Corophium* being the dominant prey species in winter and spring and *Daphnia* the dominant prey species in summer. Salmonids commonly feed on *Corophium* males, which apparently are more readily available than the larger females. *Corophium* is commonly discussed as a primary prey item of juvenile salmonids in the Lower Columbia River. *Corophium salmonis* is a euryhaline species tolerating salinities in the range of zero to 20 ppt (Holton and Higley, 1984). As shown by the above investigations, it is one of several major prey species consumed by juvenile chinook under existing conditions. No data are available that indicate its historical role in the diet of Columbia River salmon prior to substantial modification of the river system. Nutritionally, *Corophium* may not be as desirable as other food sources for young salmon. According to Higgs, *et al.* (1995), gammarid amphipods such as *Corophium* are high in chitin and ash and low in available protein and energy relative to daphnids and chironomid larvae. Subyearling chinook and chum first enter the estuary at about the same time that they enter the riverine potion of the Lower Columbia River because some of the fry move rapidly to the estuary by mid-March rather than rearing in the riverine areas (Craddock, *et al.*, 1976; Dawley, *et al.*, 1986; Levy and Northcote, 1982; Healey, 1982; Hayman, *et al.*, 1996). As chinook fry migrate to the estuary, they may remain in the low salinity or even freshwater areas for some time until they have grown somewhat larger (more than 75 mm) (Kjelson, *et al.*, 1982; Levings, 1982; Levy and Northcote, 1982; MacDonald, *et al.*, 1986; Shreffler *et al.*, 1992; Hayman, *et al.*, 1996). However, some chinook fry appear to move immediately to the outer edges and higher salinity portions of the estuary (Stober, *et al.*, 1971; Kask and Parker, 1972; Sibert, 1975; Healey, 1980; Johnson, *et al.*, 1992; Beamer, *et al.*, 2000).

Ocean-type fish commonly have the capacity to adapt to highly saline waters shortly after emergence from the gravel. Tiffan, *et al.* (2000), determined that, once active migrant fall chinook passed McNary Dam 470 km upstream from the Columbia River's mouth, 90% of the subyearlings were able to survive challenge tests in 30 ppt seawater at 18.3 degrees Celsius. Other investigators have found that very small chinook fry are capable of adapting to estuarine salinities within a few days (Ellis, 1957; Clark and Shelbourn, 1985). Wagner, *et al.* (1969), found that all fall chinook alevins tested were able to tolerate 15 to 20 ppt salinity immediately after hatching.

More than 32 species of freshwater fish have been introduced into Oregon, and are now self-sustaining, making up approximately one-third of Oregon's freshwater fish fauna. Introduced species are frequently predators on native species, compete for food resources, and alter freshwater habitats. In 1998, introduced species were found to comprise 5% of the number of species found in the upper Willamette River, but accounted for 60% of the observed species in the lower river near Portland.

Industrial harbor and port development have been significant within the Lower Columbia River watersheds, and along the mainstem Columbia River. One hundred miles of river channel within the mainstem Columbia River, its estuary – Baker Bay, and Oregon's Willamette River have been dredged as a navigation channel by the COE since 1878. Originally dredged to a depth of 20 feet minimum in 1878, the federal navigation channel of the lower Columbia River is now maintained at a depth of 40 feet and a width of 600 feet. The average amount dredged each year is 5.5 million cubic yards of material (NMFS 2002b). The lower Columbia River supports five ports on the Washington State side: Kalama, Longview, Skamania County, Woodland, and Vancouver. These ports primarily focus on the transport of timber and agricultural commodities. In addition to loss of riparian habitat, and disruption of benthic habitat due to dredging, several sediment chemical exceedances, such as arsenic, and PAHs, have been identified in Lower Columbia River watersheds in the vicinity of the ports and associated industrial activities

The most extensive urban development in the Lower Columbia River watershed occurs in the Portland/Vancouver metropolitan area. Outside of this major urban area, the majority of residential development relies on septic systems. Common water contaminants associated with urban development and residential septic systems include excessive water temperatures, lowered dissolved oxygen levels, fecal coliform, and chemicals associated with pesticides and urban runoff.

Lower Columbia River watersheds have also been significantly altered by sand and gravel mining activities both in the past and at present. Many streams and rivers have excessive sediment levels and unstable riparian areas due to in-stream mining or upland mining with poor sediment and erosion control measures.

1.5 Analysis of Effects

NOAA Fisheries' ESA regulations define "effects of the action" as "the direct and indirect effects of an action on the species or critical habitat with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline." Direct effects are immediate effects of the project on the species or its habitat, and indirect effects are those caused by the proposed action and are later in time, but are still reasonably certain to occur (50 CFR 402.02).

Direct effects result from the agency action and can include effects of interrelated and interdependent actions. Future Federal actions that are not a direct effect of the action under consideration (and not included in the environmental baseline or treated as indirect effects) are not evaluated. Indirect effects are caused by the proposed action, are later in time, and are reasonably certain to occur (50 CFR 402.02). Indirect effects can occur outside of the area directly affected by the action. Indirect effects can include the effects of other Federal actions that have not undergone section 7 consultation, but will result from the action under consultation. These actions must be reasonably certain to occur, or be a logical extension of the proposed action.

1.5.1 Effects of Proposed Actions

NOAA Fisheries believes that the proposed action may affect listed salmonids in the following ways:

1. Increased predation as a result of placement of in-water structures.
2. Other impacts resulting from placement of in-water structures.
3. Impacts resulting from construction activities.
4. Impacts resulting from changes to water quality.
5. Impacts resulting from associated boating activities.

These impacts are discussed below.

<u>Predation</u>

During migration, juvenile fall chinook salmon typically orient toward shallow, nearshore habitats (Dawley *et al.* 1986, Carrasquero 2001). Sockeye salmon and steelhead juveniles are normally found mid-river during migration (Dawley *et al.* 1986). Juvenile salmonid species such as spring chinook, sockeye, and coho salmon and up-river steelhead usually move downriver relatively quickly and in the main channel. Ledgerwood *et al.* (1991) found that subyearling chinook were found along the shoreline during the day, coho yearling chinook and sockeye salmon and steelhead were predominately found mid-river. This would aid in predator avoidance (Gray and Rondorf 1986). Fall and summer chinook salmon are found in littoral habitats and are particularly vulnerable to predation (Gray and Rondorf 1986, Tabor *et al.* 1993). Rieman *et al.* (1991) found that mortality from predation in John Day Reservoir was lower for yearling chinook and steelhead than that for subyearling chinook. Juvenile chum salmon also extensively use littoral habitats within the Columbia River estuary (Bisson *et al.* 2000). In addition, the presence of predators may force smaller prey fish species into less desirable habitats, disrupting foraging behavior, resulting in less growth (Dunsmoor *et al.* 1991).

When a salmon stock suffers from low abundance, predation can contribute significantly to its extinction (Larkin 1979). Further, providing temporary respite from predation may contribute to increasing Pacific salmon (Larkin 1979). A substantial reduction in predators will generally result in an increase in prey (in this case, salmonids) abundance (Campbell 1979). Bell (1991) states that "It is considered advantageous to reduce the rate of predation on the economically important food and sports fish species." Rieman *et al.* (1991) state that "Efforts to reduce predation could produce substantial benefits in salmon and steelhead production." Gray and Rondorf (1986), in evaluating predation in the Columbia River Basin, state that "The most effective management program may be to reduce the susceptibility of juvenile salmonids to predation by providing maximum protection during their downstream migration." Campbell (1979), discussing management of large rivers and predator-prey relations, advocates that a "do nothing" approach (as opposed to predator manipulations) coupled with a strong habitat protectionist policy, should receive serious consideration.

Predator species such as northern pikeminnow (*Ptychocheilus oregonensis*), and introduced predators such as largemouth bass (*Micropterus salmoides*), smallmouth bass (*Micropterus dolomieu*), black crappie (*Pomoxis nigromaculatus*), white crappie (*P. annularis*) and, potentially, walleye (*Stizostedion vitreum*) (Ward *et al.* 1994, Poe *et al.* 1991, Beamesderfer and Rieman 1991, Rieman *et al.* 1991, Bell 1991, Petersen *et al.* 1990, Pflug and Pauley 1984, and Collis *et al.* 1995) may use habitat created by over-water structures (Ward and Nigro 1992, Pflug and Pauley 1984, Kahler *et al.* 2000) such as piers, float houses, floats and docks (Carrasquero 2001). Rieman *et al.* (1991) opine that predation has contributed to the decline of salmon and steelhead runs in the Columbia River.

Largemouth bass are considered the principal warmwater predatory fish in the United States (Heidinger 1975, McCammon and von Geldern 1979). Habitat types utilized by largemouth bass include vegetated areas, open water and areas with cover such as docks and submerged trees (Mesing and Wicker 1986, Stuber *et al.* 1982, Miller 1975). Miller (1975) indicates that largemouth bass are primarily lake, pond and quiet water residents. Funk (1975) states that where both smallmouth and largemouth bass co-occur, largemouth bass usually inhabit quiet, weedy, backwater areas. Stuber *et al.* (1982) indicate that adult largemouth bass are most abundant in areas of low current velocities and areas with velocities greater than 20 centimeters per second (cm/sec) are unsuitable. Although they can be found in open water areas, largemouth bass are more commonly found along the shoreline (Heidinger 1975, McCammon and von Geldern 1979). During the summer, bass prefer pilings, rock formations, areas beneath moored boats, and alongside docks. Kahler *et al.* (2000) indicate that largemouth bass are often found under docks in the spring in Lake Washington. Colle *et al.* (1989) found that, in lakes lacking vegetation, largemouth bass distinctly preferred habitat associated with piers, a situation analogous to the Columbia River. Wanjala *et al.* (1986) found that adult largemouth bass in a lake were generally found near submerged structures suitable for ambush feeding.

Kahler *et al.* (2000) and Carrasquero (2001) indicate that both smallmouth and largemouth bass utilize docks and piles. Coble (1975), Miller (1975) and Edwards *et al.* (1983) indicate that smallmouth bass prefer streams with moderate currents, gravel or rubble substrate and rocks or logs creating slack water, whereas largemouth bass prefer streams with sluggish current, silt and mud substrate, and aquatic vegetation. Tabor *et al.* (1993) found that smallmouth bass may be a major predator of subyearlings due to their overlap in littoral habitat use. Edwards *et al.* (1983) state that smallmouth bass use all forms of submerged cover and prefer protection from light. Bevelhimer (1996), in studies on smallmouth bass, indicates that ambush cover and low light intensities create a predation advantage for predators and can also increase foraging efficiency. Reynolds and Casterlin (1976) indicate that smallmouth bass prefer cover affording areas of darkness. Pflug and Pauley (1984) and Carrasquero (2001) citing Kahler *et al.* (2000) states that small mouth bass in Lake Sammamish locate their nests near piers and associated in-water structures. Gilliland *et al.* (1991) in studies on smallmouth bass in Lake Texoma found that they preferred rock riprap berms that extended perpendicular to the shore. Edwards *et al.* (1983) state that both juvenile and adult smallmouth bass prefer low velocity water near a current.

Reynolds and Casterlin (1976) indicate that smallmouth and largemouth bass are crepuscular with activity peaks at dawn higher than those at dusk. Danehy and Ringler (1991) and Vigg *et al.* (1991) also indicate that smallmouth bass feed primarily at dawn and dusk. Dawley *et al.* (1986) found that migrating fall chinook salmon had diel movement peaks in the morning (0800-1100) and evening (1800-2000). Ledgerwood *et al.* (1991) found that juvenile salmonids decreased movements during darkness. This behavioral trait could facilitate increased predation by bass on juvenile salmonids, particularly during the evening hours.

Black crappie and white crappie are known to prey on juvenile salmonids (Ward *et al.* 1991). Ward *et al.* (1991), in their studies of crappies within the Willamette River, found that the highest density of crappies at their sampling sites occurred at a wharf supported by closely spaced pilings. They further indicated that suitable habitat for crappies includes pilings and riprap areas. Walters *et al.* (1991) also found that crappie were attracted to in-water structures and recommended placement of structures as attractants in lake environs.

Zimmerman and Ward (1999) found that juvenile predation by northern pikeminnow was greatest downstream of Bonneville Dam. Zimmerman (1999) found that 92% of identifiable fish remains in northern pikeminnows and 12% in smallmouth bass collected downstream of Bonneville Dam were salmonids. Ward (1992) found that stomachs of northern pikeminnow in developed areas of Portland Harbor contained 30% more salmonids than those in undeveloped areas, although undeveloped areas contained more northern pikeminnow. Giorgi *et al.* (1994) state that predatory fish, principally pikeminnow, are abundant and consume large numbers of juvenile salmonids. Ledgerwood *et al.* (1993) state that northern pikeminnow are inhabitants of slack water areas. Carrasquero (2001) indicates that northern pikeminnows are important salmonid predators in Columbia River reservoirs because of their preference for low-velocity microhabitats which are created by in-water structures. Bell (1991) states that pikeminnows are of particular concern as salmonid predators in reservoirs and slack water areas.

There are four major predatory strategies utilized by piscivorous fish: (1) They run down prey; (2) ambush prey; (3) habituate prey to a non-aggressive illusion; or (4) stalk prey (Hobson 1979). Ambush predation is probably the most common strategy: predators lie-in-wait, then dart out at the prey in an explosive rush (Gerking 1994). Kahler *et al.* (2000) state that bass are expected to benefit from structures placed in the littoral zone because of their propensity for ambush predation and preference for the littoral zone. Predators may use sheltered areas that provide slack water to ambush prey fish in faster currents (Bell 1991).

Light plays an important role in defense from predation. Prey species are better able to see predators under high light intensity, thus providing the prey species with an advantage (Hobson 1979, Helfman 1981). Petersen and Gadomski (1994) found that predator success was higher at lower light intensities. Prey fish lose their ability to school at low light intensities, making them vulnerable to predation (Petersen and Gadomski 1994). Howick and O'Brien (1983) found that in high light intensities prey species (bluegill) can locate largemouth bass before they are seen by the bass. However, in low light intensities, the bass can locate the prey before they are seen. Walters *et al.* (1991) indicate that high light intensities may result in increased use of shadeproducing structures. Helfman (1981) found that shade, in conjunction with water clarity, sunlight and vision, is a factor in attraction of temperate lake fishes to overhead structure. Carrasquero (2001) hypothesizes that shade cast by structures may disrupt juvenile migration by creating visual barriers and promoting disorientation and increasing mortality risk.

An effect of over-water structures is the creation of a light/dark interface that allows ambush predators to remain in a darkened area (barely visible to prey) and watch for prey to swim by against a bright background (high visibility). Carrasquero (2001) postulates that bass gain an element of surprise by hovering in shaded regions. Prey species moving around the structure are unable to see predators in the dark area under the structure and are more susceptible to predation.

The soldier pile breakwater with a minimum 3-foot clearance between the concrete panels and mudline should prevent creation of slack water predator areas, allow for shoreline oriented juvenile salmon passage past the breakwater and not force juveniles out into deeper water where they could be susceptible to predation nor delay passage due to a reluctance to pass. The placement of the breakwater/transient float 140 feet offshore in waters a minimum of 16 to 20 feet in depth should provide for adequate current velocities to dissuade predatory fish usage.

In addition to piscivorous predation, in-water structures (tops of pilings) also provide perching platforms for avian predators such as double-crested cormorants (*Phalacrocorax auritis*)(Kahler *et al.* 2000), from which they can launch feeding forays or dry plumage. Their high energy demands associated with flying and swimming create a need for voracious predation on live prey (Ainley 1984). Cormorants are underwater pursuit swimmers (Harrison 1983) that typically feed on mid-water schooling fish (Ainley 1984), but they are known to be highly opportunistic feeders (Derby and Lovvorn 1997; Blackwell *et al.* 1997; Duffy 1995. Double-crested cormorants are known to fish cooperatively in shallow water areas, herding fish before them (Ainley 1984). Krohn *et al.* (1995) indicate that cormorants can reduce fish populations in forage areas, thus possibly affecting adult returns as a result of smolt consumption. Because their plumage becomes wet when diving, cormorants spend considerable time drying out feathers (Harrison 1983) on pilings and other structures near feeding grounds (Harrison 1984). Placement of piles to support the dock structures will potentially provide for some usage by cormorants. Placement of anti-perching devices on the top of the pilings would preclude their use by any potential avian predators.

Carrasquero (2001) indicates that structures that modify the shoreline configuration, eliminating shore zone habitat and refugia may force juvenile salmonids into deeper water where predatory diving birds may have increased success. The installation of the soldier pile breakwater with a minimum 3-foot clearance between the concrete panels and mudline should allow for shoreline oriented juvenile salmon passage past the breakwater and not force juveniles out into deeper water where they could be susceptible to avian predation.

<u>Other In-water Structure Impacts</u>
Shading from docks, piers, boat houses, and moored boats may reduce juvenile salmonid prey organism abundance and the complexity of the habitat by reducing aquatic vegetation and

phytoplankton abundance (Kahler *et al.* 2000, Carrasquero 2001). Glasby (1999) found that epibiotic assemblages on pier pilings at marinas subject to shading were markedly different than in surrounding areas. Carrasquero (2001) citing personal observations states that juvenile salmonids will feed upon periphyton, insects and macroinverttebrates adhered to dock and pier pilings. The extent of aquatic macrophytes at the site is limited and would probably not be impacted. There would be a small amount of loss in phytoplankton production as a result of shading. The extent of epibiotic assemblages on the proposed pilings would be dependent on the type of piling material.

Riparian habitats are one of the most ecologically productive and diverse terrestrial environments (Kondolf *et al.* 1996, Naiman *et al.* 1993). Vegetation in riparian areas influences channel processes through stabilizing bank lines, and providing LW, terrestrial food sources rather than autochthonous food production, and regulating light and temperature regimes (Kondolf *et al.* 1996, Naiman *et al.* 1993). Revegetation of any riparian areas disturbed by construction activities in time will maintain or improve habitat conditions for salmonids within the action area by potentially increasing plant densities in degraded areas or changing plant species at the site to those that are more beneficial to aquatic species. The placement of a boat ramp will generally result in permanent loss of some riparian habitat. The extent of area of that loss associated with a ramp is usually small. Upland parking lots, picnic areas, walking trails, and toilet facilities will also result in losses to critical habitat if placed close to the water's edge.

In addition, construction activities associated with ramp construction will also result in impacts to the riparian area. These effects can be offset with compensatory mitigation. The riparian area at the site of the new ramp is severely degraded, but could eventually develop with time and planting efforts. The proposed plantings of 400 native trees and 800 shrubs at the site will help to offset the impacts of construction and improve the currently degraded riparian area. The removal of the old ramp and restoration of that area will also aid in increased productivity and habitat value.

Construction

In-water work associated with pile driving could result in the disturbance of juvenile fish that may be migrating through or rearing in the vicinity of the action area. Pilings made of concrete, plastic, steel, treated or untreated wood are used in many construction projects in riparian and aquatic areas. Vibratory or impact hammers are commonly used to drive piles into the substrate. An impact hammer is a heavy weight that is repeatedly dropped onto the top of the pile. A vibratory hammer uses a combination of a stationary, heavy weight, and vibration in the plane perpendicular to the long axis of the pile. The choice of hammer type depends on pile material, substrate type, and other factors. Impact hammers can drive piles into most substrates, including hardpan and glacial till, while vibratory hammers are limited to softer, unconsolidated substrates. However, over-water structures must often meet seismic stability criteria. This requires that the supporting piles be attached to, or driven into, a hard substrate and this often means that at least some impact driving is necessary. Further, the bearing capacity of a pile driven with vibration is unknown unless an impact hammer is used to 'proof' the pile by striking it pile several times to ensure it meets the designed bearing capacity. Temporary piles, fender piles, and some dolphin piles that do not need to be seismically stable can be driven with a vibratory hammer only, providing the pile type and sediments are appropriate.

Turbidity generated from pile driving or removal is temporary and confined to the area close to the operation. NOAA Fisheries expects that some individual chinook salmon and steelhead, both adult and juvenile, may be harassed by turbidity plumes resulting from pile driving or removal. Indirect lethal take can occur if individual juvenile fish are preyed on when they leave the work area to avoid temporary turbidity plumes. The requirements for completing the work during the preferred in-water work window will minimize the effects of turbidity on listed species.

Benthic invertebrates in shallow water habitats are key food sources for juvenile salmonids during their out migration. New pilings may reduce the substrate available to benthic aquatic organisms and, therefore, the food available for juvenile salmonids in the project area. NOAA Fisheries believes that some effect on salmon and steelhead productivity may occur due to suppression of benthic prey species.

Pile driving often generates intense sound pressure waves that can injure or kill fish (Reyff 2003, Abbott and Bing-Sawyer 2002, Caltrans 2001, Longmuir and Lively 2001, Stotz and Colby 2001). The type and size of the pile, the firmness of the substrate into which the pile is being driven, the depth of water, and the type and size of the pile-driving hammer all influence the sounds produced during pile driving. Sound pressure is positively correlated with the size of the pile because more energy is required to drive larger piles. Wood and concrete piles produce lower sound pressures than hollow steel piles of a similar size, and may be less harmful to fishes. Firmer substrates require more energy to drive piles and produce more intense sound pressures. Sound attenuates more rapidly with distance from the source in shallow than in deep water (Rogers and Cox 1988). Impact hammers produce intense, sharp spikes of sound that can easily reach levels that harm fishes, and the larger hammers produce more intense sounds. Vibratory hammers, on the other hand, produce sounds of lower intensity, with a rapid repetition rate.

Sound pressure levels (SPLs) greater than 150 decibels (dB) root mean square (RMS) produced when using an impact hammer to drive a pile have been shown to affect fish behavior and cause physical harm when peak SPLs exceed 180 dB (re: 1 microPascal). Surrounding the pile with a bubble curtain can attenuate the peak SPLs by approximately 20 dB and is equivalent to a 90% reduction in sound energy. However, a bubble curtain may not bring the peak and RMS SPLs below the established thresholds, and take may still occur. Without a bubble curtain, SPLs from driving 12-inch diameter steel pilings, measured at 10 meters (m), will be approximately 205 dB_{peak} (Pentec 2003) and 185 dB_{rms}. With a bubble curtain, SPLs are approximately 185 dB_{peak} and 165 dBrms. Using the spherical spreading model to calculate attenuation of the pressure wave ($TL = 50*\log(R1/R2)$), physical injury to sensitive species and life-history stages may occur up to 18 m from the pile driver, and behavioral effects up to 56 m. Studies on pile driving and underwater explosions suggest that, besides attenuating peak pressure, bubble curtains also reduce the impulse energy and, therefore, the potential for injury (Keevin 1998). Because sound pressure attenuates more rapidly in shallow water (Rogers and Cox 1988), it may have fewer deleterious effects there.

Fish respond differently to sounds produced by impact hammers than they do to sounds produced by vibratory hammers. Fish consistently avoid sounds like those of a vibratory hammer (Enger *et al.* 1993; Dolat 1997; Knudsen *et al.* 1997; Sand *et al.* 2000) and appear not to habituate to these sounds, even after repeated exposure (Dolat, 1997; Knudsen *et al.* 1997). On the other hand, fish may respond to the first few strikes of an impact hammer with a 'startle' response, but then the startle response wanes and some fish remain within the potentially-harmful area (Dolat 1997). Compared to impact hammers, vibratory hammers make sounds that have a longer duration (minutes vs. milliseconds) and have more energy in the lower frequencies (15-26 Hz vs. 100-800 Hz) (Würsig, *et al.* 2000; Carlson *et al.* 2001; Nedwell and Edwards 2002).

Air bubble systems can reduce the adverse effects of underwater sound pressure levels on fish. Whether confined inside a sleeve made of metal or fabric or unconfined, these systems have been shown to reduce underwater sound pressure (Würsig *et al.* 2000; Longmuir and Lively 2001; Christopherson and Wilson 2002; Reyff and Donovan 2003). Unconfined bubble curtains lower sound pressure by as much as 17 dB (85%) (Würsig *et al.* 2000, Longmuir and Lively 2001), while bubble curtains contained between two layers of fabric reduce sound pressure up to 22 dB (93%) (Christopherson and Wilson, 2002). However, an unconfined bubble curtain can be disrupted and rendered ineffective by currents greater than 1.15 miles per hour (Christopherson and Wilson, 2002). When using an unconfined air bubble system in areas of strong currents, it is essential that the pile be fully contained within the bubble curtain, and that the curtain have adequate air flow, and horizontal and vertical ring spacing around the pile.

The potential for take resulting from pile driving and removal will be minimized by completing the work during preferred in water work windows, using a vibratory hammer, and using sound attenuators where an impact hammer is necessary.

Short-term increases in turbidity and sedimentation may result from construction. Fine redeposited sediments have the potential to adversely affect primary and secondary productivity (Spence *et al.* 1996), and to reduce cover for juvenile salmonids (Bjornn and Reiser 1991).

The effects of suspended sediment and turbidity on fish are reported in the literature as ranging from beneficial to detrimental. Elevated total suspended solids (TSS) conditions have been reported to enhance cover conditions, reduce piscivorous fish/bird predation rates, and improve survival. Elevated TSS conditions have also been reported to cause physiological stress, reduce growth, and adversely affect survival. Of key importance in considering the detrimental effects of TSS on fish are the season, frequency and the duration of the exposure (not just the TSS concentration).

Behavioral avoidance of turbid waters may be one of the most important effects of suspended sediments (DeVore *et al.* 1980, Birtwell *et al.* 1984, Scannell 1988). Salmonids have been observed to move laterally and downstream to avoid turbid plumes (McLeay *et al.* 1984, 1987, Sigler *et al.* 1984, Lloyd 1987, Scannell 1988, Servizi and Martens 1991). Juvenile salmonids tend to avoid streams that are chronically turbid, such as glacial streams or those disturbed by human activities, except when the fish need to traverse these streams along migration routes (Lloyd *et al.* 1987). In addition, a potentially positive reported effect is providing refuge and cover from predation (Gregory and Levings 1988).

Fish that remain in turbid, or elevated TSS, waters experience a reduction in predation from piscivorous fish and birds (Gregory and Levings 1998). In systems with intense predation pressure, this provides a beneficial trade-off (e.g., enhanced survival) to the cost of potential physical effects (e.g., reduced growth). Turbidity levels of about 23 Nephalometric Turbidity Units (NTU) have been found to minimize bird and fish predation risks (Gregory 1993). Exposure duration is a critical determinant of the occurrence and magnitude of physical or behavioral effects (Newcombe and MacDonald 1991). Salmonids have evolved in systems that periodically experience short-term pulses (days to weeks) of high suspended sediment loads, often associated with flood events, and are adapted to such high pulse exposures. Adult and larger juvenile salmonids appear to be little affected by the high concentrations of suspended sediments that occur during storm and snowmelt runoff episodes (Bjornn and Reiser 1991). However, research indicates that chronic exposure can cause physiological stress responses that can increase maintenance energy and reduce feeding and growth (Redding *et al.* 1987, Lloyd 1987, Servizi and Martens 1991).

At moderate levels, turbidity has the potential to adversely affect primary and secondary productivity, and at high levels, has the potential to injure and kill adult and juvenile fish. Turbidity might also interfere with feeding (Spence *et al.* 1996). Newly-emerged salmonid fry may be vulnerable to even moderate amounts of turbidity (Bjornn and Reiser 1991). Other behavioral effects on fish, such as gill flaring and feeding changes, have been observed in response to pulses of suspended sediment (Berg and Northcote 1985). Fine redeposited sediments also have the potential to adversely affect primary and secondary productivity (Spence *et al.* 1996), and to reduce incubation success (Bell 1991) and cover for juvenile salmonids (Bjornn and Reiser 1991).

Larger juvenile and adult salmon appear to be little affected by ephemerally-high concentrations of suspended sediments that occur during most storms and episodes of snow melt. However, other research demonstrates that feeding and territorial behavior can be disrupted by short-term exposure to turbid water. Localized increases of turbidity during in-water work will likely displace fish in the project area and disrupt normal behavior. Therefore, there is a low probability of direct mortality from turbidity associated with the proposed activity because of the coarse grained sand material on site and any turbidity should be localized and brief.

<u>Water Quality</u>
Water quality may be affected by runoff from associated parking lots. Fuel, lubricants, etc., could injure or kill aquatic organisms. Parking lots have the potential to indefinitely transmit contaminants to waterbodies, if a hydrologic connection (*e.g.* ditch) exists. Petroleum-based

contaminants, such as fuel, oil, and some hydraulic fluids, contain polycyclic aromatic hydrocarbons (PAHs) which can cause acute toxicity to salmonids at high levels of exposure and can also cause chronic lethal as well as acute and chronic sublethal effects to aquatic organisms (Neff 1985). The placement of curbs around the parking lot will send surface water to the existing city storm system. The extent of runoff should be no greater than that currently experienced at the existing facility. Boating also affects water quality through the input of PAHs from two cycle outboard motors, turbulence created by propellers and wave erosion along the shoreline (Mosisch and Arthington 1998).

Treated wood used for pilings and docks releases contaminants into both fresh and saltwater environs. PAHs are commonly released from creosote treated wood. PAHs may cause a variety of deleterious effects (cancer, reproductive anomalies, immune dysfunction, and growth and development impairment) to exposed fish (Johnson 2000, Johnson *et al.* 1999, Stehr *et al.* 2000). Wood also is commonly treated with other chemicals such as ammoniacal copper zinc arsenate (ACZA) and chromated copper arsenate (CCA) (Poston 2001). Direct exposure to the contaminants occurs as salmon migrate past installations with treated wood or when the area is used for rearing, and indirect exposure occurs through ingestion of other organisms that have been exposed (Posten 2001). Leaching rates of contaminants from treated wood is highly variable and dependent on many factors (Posten 2001). Consequently, Posten (2001) recommends that use of treated wood for each individual situation needs to be evaluated on its own merits and subject to an evaluation of the pertinent conditions at each site. The use of steel piles for dock supports will alleviate treated piling concerns. No treated wood is proposed for float construction.

<u>Boating Activities</u>
Power boating can be deleterious to aquatic environments (Mosisch and Arthington 1998). Public boat ramps and docks are likely to have high levels of boating activity in their immediate vicinity, particularly adjacent to floats. Specifically, docks serve as a mooring area for boats or a staging platform for recreational boating activities. There are several impacts boating activities may have on listed salmonids and aquatic habitat. Directly, engine noise, prop movement, and the physical presence of a boat hull may disrupt or displace nearby fishes (Mueller 1980, Warrington 1999a). This may result in delayed upstream migration, in particular to those fish returning to Fox Creek.

Boat traffic may also cause: (1) Increased turbidity in shallow waters; (2) uprooting of aquatic macrophytes in shallow waters; (3) aquatic pollution, through exhaust, fuel spills, or release of petroleum lubricants (Warrington 1999b, Mosisch and Arthington 1998); (4) reduction of shallow water invertebrate abundance (Carrasquero 2001 citing Lagler *et al.* 1950); or (5) bank erosion from wakes (Mosisch and Arthington 1998). These boating impacts indirectly affect listed fish in a number of ways. Turbidity may injure or stress affected fishes. The loss of aquatic macrophytes may expose salmonids to predation, decrease littoral productivity, or alter local species assemblages and trophic interactions. However, the proposed action area may be lacking in aquatic macrophytes. Despite a general lack of data specifically for salmonids, pollution from boats may cause short-term injury, physiological stress, decreased reproductive success, cancer, or death for fishes in general. Further, pollution may also impact fishes by impacts to potential prey species or aquatic vegetation.

1.5.2 Effects on Critical Habitat

NOAA Fisheries designates critical habitat based on physical and biological features that are essential to the listed species. Essential features for designated critical habitat include substrate, water quality, water quantity, water temperature, food, riparian vegetation, access, water velocity, space and safe passage. For the proposed action, NOAA Fisheries believes that the effects to critical habitat are included in the effects described above.

1.5.3 Cumulative Effects

Cumulative effects are defined in 50 CFR 402.02 as "those effects of future State or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation." Other activities within the watershed have the potential to impact fish and habitat within the action area. Future Federal actions, including the ongoing operation of hydropower systems, hatcheries, fisheries, and land management activities will be reviewed through separate section 7 consultation processes. NOAA Fisheries is not aware of any significant change in non-federal activities that are reasonably certain to occur. NOAA Fisheries assumes that future private and state actions will continue at similar intensities as in recent years.

1.6 Conclusion

After reviewing the best scientific and commercial information available regarding the current status of the 12 ESUs of listed salmonids considered in this Opinion, the environmental baseline for the action area, the effects of the proposed action, and the cumulative effects, it is NOAA Fisheries' opinion, that the proposed Rainier Boat Ramp is not likely to jeopardize the continued existence of these species, and it is not likely to destroy or adversely modify designated critical habitat. This conclusion is based on the following: (1) In-water structures are designed in such a way as to minimize the potential for predator usage and allow for juvenile fish passage by the facility; (2) construction impacts should be minimized by the proposed timing of construction work and methodologies; (3) water quality impacts should be minimal or not increased beyond that already experienced at the ramp being removed; and (4) the proposed plantings should improve the riparian areas at both sites.

1.7 Reinitiation of Consultation

Consultation must be reinitiated if: The amount or extent of taking specified in the incidental take statement is exceeded, or is expected to be exceeded; new information reveals effects of the action may affect listed species in a way not previously considered; the action is modified in a way that causes an effect on listed species that was not previously considered; or, a new species is listed or critical habitat is designated that may be affected by the action (50 CFR 402.16). To re-initiate consultation, the COE should contact the Habitat Conservation Division (Oregon Habitat Branch) of NOAA Fisheries.

2. INCIDENTAL TAKE STATEMENT

The ESA at section 9 [16 USC 1538] prohibits take of endangered species. The prohibition of take is extended to threatened anadromous salmonids by section 4(d) rule [50 CFR 223.203]. Take is defined by the statute as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct." [16 USC 1532(19)] Harm is defined by regulation as "an act which actually kills or injures fish or wildlife. Such an act may include significant habitat modification or degradation which actually kills or injures fish or wildlife by significantly impairing essential behavior patterns, including, breeding, spawning, rearing, migrating, feeding or sheltering." [50 CFR 222.102] Harass is defined as "an intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering." [50 CFR 17.3] Incidental take is defined as "takings that result from, but are not the purpose of, carrying out an otherwise lawful activity conducted by the Federal agency or applicant." [50 CFR 402.02] The ESA at section 7(o)(2) removes the prohibition from any incidental taking that is in compliance with the terms and conditions specified in a section 7(b)(4) incidental take statement [16 USC 1536].

An incidental take statement specifies the impact of any incidental taking of endangered or threatened species. It also provides reasonable and prudent measures that are necessary to minimize impacts and sets forth terms and conditions with which the action agency must comply in order to implement the reasonable and prudent measures.

2.1 Amount or Extent of the Take

NOAA Fisheries anticipates that the proposed action is reasonably certain to result in incidental take of listed salmonids because of detrimental effects from increased sediment levels, the potential to injure or kill listed species during in-water work, the potential for incidental take by increasing predation, and the alteration of migration behavior resulting from inwater structures and boating traffic. Effects of actions such as these are largely unquantifiable in the short term, and are not expected to be measurable as long-term effects on habitat or population levels. Therefore, even though NOAA Fisheries expects some low level incidental take to occur due to the actions covered by this Opinion, the best scientific and commercial data available are not sufficient to enable NOAA Fisheries to estimate a specific amount of incidental take to the species itself. In instances such as these, NOAA Fisheries designates the expected level of take as "unquantifiable". Based on the information in the BA, NOAA Fisheries anticipates that an unquantifiable amount of incidental take could occur as a result of the actions covered by this Opinion. The extent of the take is limited to the area within a 100-foot radius of the old ramp (river mile 67.9), upstream of the new ramp to Fox Creek, and downstream to the visible limits of turbidity.

2.2 Reasonable and Prudent Measures

NOAA Fisheries believes that the following reasonable and prudent measures are necessary and appropriate to avoid or minimize take of the above species.

The COE shall:

1. Avoid and minimize the amount and extent of incidental take from general construction activities by applying permit conditions that avoid or minimize adverse effects to riparian and aquatic systems.

2. Avoid and minimize the amount and extent of take from site preparation for related structures by excluding unauthorized permit actions and applying permit conditions that avoid or minimize effects to riparian and aquatic systems.

3. Avoid and minimize incidental take from recreational boating facilities by excluding unauthorized permit actions and applying permit conditions that avoid or minimize effects to riparian and aquatic systems.

4. Aviod and minimize take from streambank protection by applying permit conditions that provide the greatest degree of natural floodplain and stream functions achievable through the use of an integrated, ecological approach.

5. Ensure completion of a comprehensive monitoring and reporting program to confirm that the terms and conditions are meeting the objective of minimizing take.

2.3 Terms and Conditions

In order to be exempt from the prohibitions of section 9 of the ESA, the COE must comply with the following terms and conditions, which implement the reasonable and prudent measures described above. These terms and conditions are non-discretionary.

1. To implement reasonable and prudent measure #1 (construction), the COE shall ensure that:

    a. All inwater work occurs between November 1 and February 28.
    b. Pollution and Erosion Control Plan. A Pollution and Erosion Control Plan will be prepared and carried out to prevent pollution related to construction operations. The plan must be available for inspection on request by COE or NOAA Fisheries.
        i. Plan Contents. The Pollution and Erosion Control Plan must contain the pertinent elements listed below, and meet requirements of all applicable laws and regulations.
            (1) Practices to prevent erosion and sedimentation associated with access roads, stream crossings, construction sites, borrow pit

operations, haul roads, equipment and material storage sites, fueling operations and staging areas.

(2) Practices to confine, remove and dispose of excess concrete, cement and other mortars or bonding agents, including measures for washout facilities.

(3) A description of any hazardous products or materials that will be used for the project, including procedures for inventory, storage, handling, and monitoring.

(4) A spill containment and control plan with notification procedures, specific clean up and disposal instructions for different products, quick response containment and clean up measures that will be available on the site, proposed methods for disposal of spilled materials, and employee training for spill containment.

(5) Practices to prevent construction debris from dropping into any stream or waterbody, and to remove any material that does drop with a minimum disturbance to the streambed and water quality.

ii. Inspection of erosion controls. During construction, all erosion controls must be inspected daily during the rainy season and weekly during the dry season to ensure they are working adequately.[2]

(1) If inspection shows that the erosion controls are ineffective, work crews must be mobilized immediately to make repairs, install replacements, or install additional controls as necessary.

(2) Sediment must be removed from erosion controls once it has reached 1/3 of the exposed height of the control.

c. Construction discharge water. All discharge water created by construction (*e.g.*, concrete washout, pumping for work area isolation, vehicle wash water) will be treated as follows:

i. Water quality. Facilities must be designed, built and maintained to collect and treat all construction discharge water using the best available technology applicable to site conditions. The treatment must remove debris, nutrients, sediment, petroleum hydrocarbons, metals and other pollutants likely to be present.

ii. Discharge velocity. If construction discharge water is released using an outfall or diffuser port, velocities must not exceed 4 feet per second.

iii. Spawning areas, marine submerged vegetation. No construction discharge water may be released within 300 feet upstream of active spawning areas or areas with marine submerged vegetation.

d. Preconstruction activity. Before significant[3] alteration of the project area, the following actions must be completed:

---

[2] "Working adequately" means no turbidity plumes are evident during any part of the year.

[3] "Significant" means an effect can be meaningfully measured, detected or evaluated.

i. Marking. Flag the boundaries of clearing limits associated with site access and construction to prevent ground disturbance of critical riparian vegetation, wetlands and other sensitive sites beyond the flagged boundary.

ii. Emergency erosion controls. Ensure that the following materials for emergency erosion control are onsite.

(1) A supply of sediment control materials (*e.g.*, silt fence, straw bales[4]).

(2) An oil-absorbing, floating boom whenever surface water is present.

iii. Temporary erosion controls. All temporary erosion controls must be in-place and appropriately installed downslope of project activity within the riparian area until site restoration is complete.

e. Heavy Equipment. Use of heavy equipment will be restricted as follows.

i. Choice of equipment. When heavy equipment must be used, the equipment selected must have the least adverse effects on the environment (*e.g.*, minimally-sized, rubber-tired).

ii. Vehicle staging. Vehicles must be fueled, operated, maintained and stored as follows:

(1) Vehicle staging, cleaning, maintenance, refueling, and fuel storage must take place in a vehicle staging area placed 150 feet or more from any stream, waterbody or wetland.

(2) All vehicles operated within 150 feet of any stream, waterbody or wetland must be inspected daily for fluid leaks before leaving the vehicle staging area. Any leaks detected must be repaired in the vehicle staging area before the vehicle resumes operation. Inspections must be documented in a record that is available for review on request by the COE or NOAA Fisheries.

(3) All equipment operated instream must be cleaned before beginning operations below the bankfull elevation to remove all external oil, grease, dirt, and mud.

(4) Stationary power equipment. Stationary power equipment (*e.g.*, generators, cranes) operated within 150- eet of any stream, waterbody or wetland must be diapered to prevent leaks, unless otherwise approved in writing by NOAA Fisheries.

f. Site preparation. Native materials will be conserved for site restoration.

i. If possible, native materials must be left where they are found.

ii. Materials that are moved, damaged or destroyed must be replaced with a functional equivalent during site restoration.

---

[4] When available, certified weed-free straw or hay bales must be used to prevent introduction of noxious weeds.

iii. Any large wood[5], native vegetation, weed-free topsoil, and native channel material displaced by construction must be stockpiled for use during site restoration.

g. Earthwork. Earthwork (including drilling, excavation, dredging, filling and compacting) will be completed as quickly as possible.

i. Site stabilization. All disturbed areas must be stabilized, including obliteration of temporary roads, within 12 hours of any break in work unless construction will resume work within 7 days between June 1 and September 30, or within 2 days between October 1 and May 31.

ii. Source of materials. Boulders, rock, woody materials and other natural construction materials used for the project must be obtained outside the riparian area.

h. Piling installation. Install temporary and permanent pilings as follows:

i. Minimize the number and diameter of pilings, as appropriate, without reducing structural integrity.

ii. Repairs, upgrades, and replacement of existing pilings consistent with these terms and conditions are allowed.

iii. In addition to repairs, upgrades, and replacements of existing pilings, up to five single pilings or one dolphin consisting of three to five pilings may be added to an existing facility per in-water construction period.

iv. Drive each piling as follows to minimize the use of force and resulting sound pressure.

(1) Hollow steel pilings greater than 24 inches in diameter, and H-piles larger than designation HP24, are not authorized under this Opinion.

(2) When impact drivers will be used to install a pile, use the smallest driver and the minimum force necessary to complete the job. Use a drop hammer or a hydraulic impact hammer, whenever feasible and set the drop height to the minimum necessary to drive the piling.

(3) When using an impact hammer to drive or proof steel piles, one of the following sound attenuation devices will be used to reduce sound pressure levels by 20 decibels.

(a) Place a block of wood or other sound dampening material between the hammer and the piling being driven.

(b) If currents are 1.7 miles per hour or less, surround the piling being driven by an unconfined bubble curtain that

---

[5] For purposes of this Opinion only, "large wood" means a tree, log, or rootwad big enough to dissipate stream energy associated with high flows, capture bedload, stabilize streambanks, influence channel characteristics, and otherwise support aquatic habitat function, given the slope and bankfull width of the stream in which the wood occurs. See, Oregon Department of Forestry and Oregon Department of Fish and Wildlife, *A Guide to Placing Large Wood in Streams*, May 1995 (www.odf.state.or.us/FP/RefLibrary/LargeWoodPlacemntGuide5-95.doc).

will distribute small air bubbles around 100% of the piling perimeter for the full depth of the water column.[6]

(c) If currents greater than 1.7 miles per hour, surround the piling being driven by a confined bubble curtain (*e.g.*, a bubble ring surrounded by a fabric or metal sleeve) that will distribute air bubbles around 100% of the piling perimeter for the full depth of the water column.

(d) Other sound attenuation devices as approved in writing by NOAA Fisheries.

2. To implement reasonable and prudent measure #2 (site preparation for buildings and related structures), the COE shall ensure that:

   a. No buildings or related structures or stormwater detention facilities are authorized under this Opinion within 70 feet of the top of bank within the action area.
   b. Construction. All site preparation for buildings and related structure activities involving temporary access roads, use of heavy equipment, earthwork, site restoration, or that may otherwise involve in-water work or affect fish passage, must also meet all applicable terms and conditions to implement reasonable and prudent measure #1 (construction).
   c. Stormwater management. All stormwater runoff from any building or related structure built as a result of site preparation authorized under this Opinion must be managed to ensure that it will meet state water quality standards for temperature, turbidity, and other criteria before it reaches a receiving water and will not significantly alter instream flow rates, including the timing, magnitude or duration of instream peak flows.

3. To implement reasonable and prudent measure #3 (boat ramps), the COE shall ensure that:

   a. Construction. All aquatic facility activities involving temporary access roads, use of heavy equipment, earthwork, site restoration, or that may otherwise involve in-water work or affect fish passage, must also meet all applicable terms and conditions to implement reasonable and prudent measure #1 (construction).
   b. Access walkways, docks and related features. All access walkways, docks and related features will be constructed as follows:
      i. All walkways, docks, and related features wider than 6 feet will include grating, translucent panels, or other light diffusers to maintain a minimum

[6] For guidance on how to deploy an effective, economical bubble curtain, see, Longmuir, C. and T. Lively, *Bubble Curtain Systems for Use During Marine Pile Driving*, Fraser River Pile and Dredge LTD, 1830 River Drive, New Westminster, British Columbia, V3M 2A8, Canada. Recommended components include a high volume air compressor that can supply more than 100 pounds per square inch at 150 cubic feet per minute to a distribution manifold with 1/16 inch diameter air release holes spaced every 3/4 inch along its length. An additional distribution manifold is needed for each 35 feet of water depth.

of 60% of the ambient light levels unless: (1) Current velocity is greater than 0.7 feet per second; (2) the float is greater than 50 feet from the shoreline; and (3) the float is in water deeper than 20 feet at lowest flow.

ii. All flotation will be encapsulated to permanently prevent the breakup loss of flotation.

iii. Boarding floats may not ground out at any time under any flow except on the concrete boat ramp.

c. Piscivorus bird deterrence. All pilings and navigational aids, such as moorings, and channel markers, will be fitted with devices to prevent perching by piscivorus bird species.

d. Non-water dependent facilities. All parking lots, picnic areas, toilets, trails and other non-water dependent facilities will be constructed as follows:

i. All non-water dependent facilities will be 70 feet or more from the top of the bank.

ii. All runoff from parking lots and other impervious surfaces will be collected and treated to remove contaminants prior to return to any receiving waters. All runoff will meet state water quality standards for temperature, turbidity, and other state water quality criteria before it reaches a receiving water and will not significantly alter instream flow, including the timing, magnitude or duration of instream peak flows.

e. No vessels may be allowed to beach or anchor within 150 feet of the beach, from 200 feet downstream of the proposed ramp upstream to the mouth of Fox Creek. The applicant shall post signs along the beach notifying users of the prohibition.

f. Vessel speed shall be limited to 5 miles per hour within 150 feet of the shoreline, from 200 feet downstream of the proposed ramp upstream to the mouth of Fox Creek. The applicant shall post notices of this limit at the ramp and place speed limit bouys within the river delimiting the restricted speed area.

g. Rock armoring may occur only along the sides of the ramp, must be 350 class metric in size and may extend no further than 10 feet from the edge of the ramp.

h. Educational Signs. Because the best way to minimize adverse eefects caused by boating is to educate the public about pollution and its prevention, the COE shall require the applicant to post and maintain the following information at the boat ramp:

i. A description of the ESA-listed salmonids which are present in the project area.

ii. Notice that the adults and juveniles of these species, and their habitats, are to be protected so that they can successfully migrate, spawn, rear, and complete other behaviors.

iii. Lack of necessary habitat conditions may result in a variety of adverse effects including mortality, migration delay, reduced spawning, food loss, reduced growth and reduced populations.

iv. Therefore, all users of the facility are encouraged and required to minimize fuel and oil released into surface waters from bilges and gas tanks; avoid cleaning boats in areas where the water can re-enter the stream; practice sound fish cleaning and waste management; and dispose of all solid and liquid waste produced while boating in a proper facility away from surface waters.

4. To implement reasonable and prudent measure #4 (streambank restoration/protection), the COE shall ensure that:

   a. All actions intended for streambank protection will also provide the greatest degree of natural stream and floodplain function achievable through application of an integrated, ecological approach.
   b. Woody riparian planting must be included as a project component.

5. To implement reasonable and prudent measure #5 (monitoring), the COE shall:

   a. Ensure that the applicant submits a monitoring report to the COE within 120 days of project completion describing the applicant's success meeting permit conditions. Each project level monitoring report will include the following information:
      i. <u>Project identification</u>
         (1) Permittee name, permit number, and project name.
         (2) Project location, including any compensatory mitigation site(s), by 5th field HUC and by latitude and longitude as determined from the appropriate USGS 7-minute quadrangle map
         (3) COE contact person.
         (4) Starting and ending dates for work completed
      ii. <u>Narrative assessment</u>. A narrative assessment of the project's effects on natural stream function.
      iii. <u>Photo documentation</u>. Photo of habitat conditions at the project and any compensation site(s), before, during, and after project completion.[7]
         (1) Include general views and close-ups showing details of the project and project area, including pre and post construction.
         (2) Label each photo with date, time, project name, photographer's name, and a comment about the subject.
      ii. <u>Other data</u>. Additional project-specific data, as appropriate for individual projects.
         (1) <u>Work cessation</u>. Dates work cessation was required due to high flows.
         (2) <u>Fish screen</u>. Compliance with NOAA Fisheries' fish screen criteria.

---

[7] Relevant habitat conditions may include characteristics of channels, eroding and stable streambanks in the project area, riparian vegetation, water quality, flows at base, bankfull and over-bankfull stages, and other visually discernable environmental conditions at the project area, and upstream and downstream of the project.

(3) A summary of pollution and erosion control inspections, including any erosion control failure, hazardous material spill, and correction effort.

(4) Site preparation.
   (a) Total cleared area – riparian and upland.
   (b) Total new impervious area.

(5) Isolation of in-water work area, capture and release.
   (a) Supervisory fish biologist – name and address.
   (b) Methods of work area isolation and take minimization.
   (c) Stream conditions before, during and within one week after completion of work area isolation.
   (d) Means of fish capture.
   (e) Number of fish captured by species.
   (f) Location and condition of all fish released.
   (g) Any incidence of observed injury or mortality.

(6) Streambank protection.
   (a) Completed screening matrices used to select treatments.
   (b) Type and amount of materials used.
   (c) Project size – one bank or two, width and linear feet.

(7) Water dependent structures and related features.
   (a) Area of new over-water structure.
   (b) Streambank distance to nearest existing water dependent structure -- upstream and down.

(8) Minor discharge and excavation/maintenance dredging.
   (a) Volume of dredged material.
   (b) Water depth before dredging and within one week of completion.
   (c) Verification of upland dredge disposal.

(9) Site restoration.
   (a) Finished grade slopes and elevations.
   (b) Log and rock structure elevations, orientation, and anchoring (if any).
   (c) Planting composition and density.
   (d) A five-year plan to:
      (i) Inspect and, if necessary, replace failed plantings to achieve 100% survival at the end of the first year, and 80% survival or 80% coverage after five years (including both plantings and natural recruitment).
      (ii) Control invasive non-native vegetation.
      (iii) Protect plantings from wildlife damage and other harm.
      (iv) Provide the COE annual progress reports.

(10) Long-term habitat loss. This will consist of the same elements as monitoring for site restoration.

3. MAGNUSON-STEVENS ACT

Public Law 104-267, the Sustainable Fisheries Act of 1996, amended the Magnuson-Stevens Fishery Conservation and Management Act (MSA) to establish new requirements for *Essential Fish Habitat* (EFH) descriptions in Federal fishery management plans and to require Federal agencies to consult with NOAA Fisheries on activities that may adversely affect EFH. EFH "means those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity" (MSA § 3). This definition includes those waters and substrate necessary to ensure the production needed to support a long-term sustainable fishery (*i.e.*, properly functioning habitat conditions necessary for the long-term survival of the species through the full range of environmental variation).

Section 305(b) of the MSA (16 U.S.C. 1855(b)) requires that:

- Federal agencies must consult with NOAA Fisheries on all actions, or proposed actions, authorized, funded, or undertaken by the agency, that may adversely affect EFH;

- NOAA Fisheries shall provide conservation recommendations for any Federal or state activity that may adversely affect EFH;

- Federal agencies shall, within 30 days after receiving conservation recommendations from NOAA Fisheries, provide a detailed response in writing to NOAA Fisheries regarding the conservation recommendations. The response shall include a description of measures proposed by the agency for avoiding, mitigating, or offsetting the impact of the activity on EFH. In the case of a response that is inconsistent with the conservation recommendations of NOAA Fisheries, the Federal agency shall explain its reasons for not following the recommendations.

The MSA does not distinguish between actions in EFH and actions outside of EFH, such as upstream and upslope activities that may have an adverse effect on EFH. Therefore, EFH consultation with NOAA Fisheries is required by Federal agencies undertaking, permitting, or funding an activity that may adversely affect EFH, regardless of its location.

The Pacific Fisheries Management Council (PFMC) has designated EFH for three species of Pacific salmon: Chinook (*Oncorhynchus tshawytscha*); coho (*O. kisutch*); and Puget Sound pink salmon (*O. gorbuscha*) (PFMC 1999). Freshwater EFH for Pacific salmon includes all those streams, lakes, ponds, wetlands, and other waterbodies currently, or historically accessible to salmon in Washington, Oregon, Idaho, and California, except areas upstream of certain impassable man-made barriers (as identified by the PFMC), and longstanding, naturally-impassable barriers (*i.e.*, natural waterfalls in existence for several hundred years). Detailed descriptions and identifications of EFH for salmon are found in Appendix A to Amendment 14 to the *Pacific Coast Salmon Plan* (PFMC 1999). Assessment of the impacts to these species' EFH from the proposed action is based on this information.

3.1 Effects of Proposed Action

The proposed action is described in the ESA section above. The action area is the Columbia River, within a 100-foot radius of the old ramp (river mile 67.9), the new ramp (river mile 67.2), upstream of the new ramp to Fox Creek, and downstream to the limits of short-term visible turbidity in the Columbia River at Rainier, Oregon, which has been designated as EFH for various life stages of chinook and coho salmon and starry flounder (*Platyichthys stellatus*). Information submitted by the COE in the BA is sufficient for NOAA Fisheries to conclude that the effects of the proposed actions will adversely affect EFH.

3.2 EFH Conservation Recommendations

Pursuant to section 305(b)(4)(A) of the MSA, NOAA Fisheries is required to provide EFH conservation recommendations for any Federal or state agency action that would adversely affect EFH. The terms and conditions outlined in section 2.3, above, are generally applicable to designated EFH for chinook and coho salmon and starry flounder and address these adverse effects. Consequently, NOAA Fisheries incorporates them here as EFH conservation recomendations.

3.3 Statutory Response Requirement

Please note that the MSA (section 305(b)) and 50 CFR 600.920(j) requires the Federal agency to provide a written response to NOAA Fisheries' EFH conservation recommendations within 30 days of its receipt of this letter.

3.4 Supplemental Consultation

The COE must reinitiate EFH consultation with NOAA Fisheries if the proposed action is substantially revised in a manner that may adversely affect EFH, or if new information becomes available that affects the basis for NOAA Fisheries' EFH conservation recommendations (50 CFR Part 600.920).

4. LITERATURE CITED

Argue, A.W., B. Hillaby, and C.D. Shepard. 1985. Distribution, Timing, Change in Size, and Stomach Contents of Juvenile Chinook and Coho Salmon Caught in Cowichan Estuary and Bay, 1973, 1975, 1976. Canadian Technical Report of Fisheries and Aquatic Sciences No. 1431. 145 pp.

Arkoosh, M. R., E. Casillas, E. Clemons, B. McCain, and U. Varanasi. 1991. Suppression of immunological memory in juvenile chinook salmon (*Oncorhynchus tshawytscha*) from an urban estuary. Fish & Shellfish Immunology 1:261-277.

Arkoosh, M. R., E. Clemons, M. Myers, and E. Casillas. 1994. Suppression of B-cell mediated immunity in juvenile chinook salmon (*Oncorhynchus tshawytscha*) after exposure to either a polycyclic aromatic hydrocarbon or to polychlorinated biphenyls. Immunopharmacology and Immunotoxicology 16(2):293- 314.

Arkoosh, M. R, E. Casillas, P. Huffman, E. Clemons, J. Evered, J.E. Stein, and U. Varanasi. 1998. Increased susceptibility of juvenile chinook salmon (*Oncorhynchus tshawytscha*) from a contaminated estuary to the pathogen *Vibrio anguillarum*. Transactions of the American Fisheries Society 127:360-374.

Beamer, E.M., J.C. Sartori, and K.A Larsen. 2000. Skagit Chinook Life History Study Progress Report Number 3. Unpublished Report by Skagit System Cooperative, Laconner, Washington. 20 pp.

Beamesderfer, R.C. and B.E. Rieman. 1991. Abundance and Distribution of Northern Squawfish, Walleyes, and Smallmouth Bass in John Day Reservoir, Columbia River. Transactions of the American Fisheries Society 120:439-447.

Bell, M. C. 1991. Fisheries handbook of Engineering requirements and biological criteria. Fish Passage Development and Evaluation Program. U.S. Army Corps of Engineers, North Pacific Division.

Berg, L. and T. G. Northcote. 1985. Changes in territorial, gill-flaring, and feeding behavior in juvenile coho salmon (*Oncorhynchus kisutch*) following short-term pulses of suspended sediment. Canadian Journal of Fisheries and Aquatic Sciences 42:1410-1417.

Bevelhimer, M.S. 1996. Relative importance of temperature, food and physical structure to habitat choice by smallmouth bass in laboratory experiments. Transactions of the American Fisheries Society. 125:274-283.

Birtwell, I. K., G. F. Hartman, B. Anderson, D. J. McLeay, and J. G. Malick. 1984. A brief investigation of arctic grayling (*Thymallus arcticus*) and aquatic invertebrates in the Minto Creek drainage, Mayo, Yukon Territory: An area subjected to placer mining. Canadian Technical Report of Fisheries and Aquatic Sciences 1287.

Bjornn, T. C., and D. W. Reiser. 1991. Habitat requirements of salmonids in streams. Pages 83-138 *in* W. R. Meehan, ed. Influences of forest and rangeland management on salmonid fishes and their habitats. American Fisheries Society Special Publication 19:83-138.

Bottom, D. L., K. K. Jones, and M. J. Herring. 1984. Fishes of the Columbia River estuary. Columbia River Estuary Data Development Program. 113 p.

BRT (Biological Review Team). 1997. Status review update for West Coast steelhead from Washington, Idaho, Oregon, and California. National Marine Fisheries Service, West Coast Steelhead BRT, Portland, Oregon.

Bugert, R., P. LaRiviere, D. Marbach, S. Martin, L. Ross, and D. Geist. 1990. 1989 Annual Report of Lower Snake River Compensation Plan, Salmon Hatchery Evaluation Program, to U.S. Fish and Wildlife Service (Cooperative Agreement 14-16-0001-89525).

Burgner, R.L. 1991. Life history of sockeye salmon (*Oncorhynchus nerka*). Pages 1-117 *In:* Groot, C. and L. Margolis (eds.). 1991. Pacific salmon life histories. Vancouver, British Columbia: University of British Columbia Press.

Busack, C. 1991. Genetic evaluation of the Lyons Ferry Hatchery stock and wild Snake River fall chinook. Washington Department of Fisheries, Report to ESA Administrative Record for Fall Chinook Salmon, Olympia.

Busby, P., S. Grabowski, R. Iwamoto, C. Mahnken, G. Matthews, M. Schiewe, T. Wainwright, R. Waples, J. Williams, C. Wingert, and R. Reisenbichler. 1995. Review of the status of steelhead (*Oncorhynchus mykiss*) from Washington, Idaho, Oregon, and California under the U.S. Endangered Species Act. 102 p. plus 3 appendices.

Busby, P.J., T.C. Wainwright, G.J. Bryant, L.J. Lierheimer, R.S. Waples, F.W. Waknitz, and I.V. Lagomarsino. 1996. Status review of west coast steelhead from Washington, Idaho, Oregon, and California. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-NWFSC-27, 261p.

Busby, P., and 10 co-authors. 1999. Updated status of the review of the Upper Willamette River and Middle Columbia River ESUs of steelhead *(Oncorhynchus mykis*s). National Marine Fisheries Service, Northwest Fisheries Science Center, West Coast Biological Review Team, Seattle, Washington.

Campbell, K.P. 1979. Predation principles in large rivers: A review. Pages 181-191 in R.H. Stroud and H. Clepper, editors. Predator-prey systems in fisheries management. Sport Fishing Institute, Washington D.C.

Carlson, T.J., G.R. Ploskey, R.L. Johnson, R.P. Mueller, M.A. Weiland and P.N. Johnson. 2001. Observations of the behavior and distribution of fish in relation to the Columbia River navigation channel and channel maintenance activities. Pacific Northwest National Laboratory, Richland, WA.

Carrasquero, J. 2001. Over-water Structures: Freshwater Issues. White paper submitted to Washington Department of Fish and Wildlife, Washington Department of Ecology and Washington Department of Transportation. www.wa.gov/wdfw/hab/ahg. 101 pp.

Casillas E., M.R. Arkoosh, E. Clemons, T. Hom, D. Misitano, T.K. Collier, J.E. Stein, and U. Varanasi. 1995a. Chemical contaminant exposure and physiological effects in out-migrant juvenile chinook salmon from urban estuaries of Puget Sound, Washington. In Puget Sound Research 95; Proceedings. Puget Sound Water Quality Authority, PO Box 40900, Olympia, WA 98504. Pp. 657-665.

Casillas E., M.R. Arkoosh, E. Clemons, T. Hom, D. Misitano, T.K. Collier, J.E. Stein, and U. Varanasi. 1995b. Chemical contaminant exposure and physiological effects in out-migrant juvenile chinook salmon from selected urban estuaries of Puget Sound, Washington. In Salmon Ecosystem Restoration: Myth and Reality: Proceedings of the 1994 Northeast Pacific Chinook and Coho Salmon Workshop, M. Keefe (ed.), American Fisheries Society, Oregon Chapter, Corvallis, OR. Pp. 85-102.

Casillas, E., B-T. L. Eberhart, T.K. Collier, M.M. Krahn, and J.E. Stein. 1998. Exposure of juvenile chinook salmon to chemical contaminants specific to the Hylebos Waterway: Tissue concentrations and biochemical responses. Interpretive Report prepared for NOAA Damage Assessment Center.

CBFWA (Columbia Basin Fish and Wildlife Authority). 1990. Snake River subbasin (mainstem from mouth to Hells Canyon Dam) salmon and steelhead production plan. CBFWA, Northwest Power Planning Council, Portland, Oregon.

Chapman, D., A. Giorgi, M. Hill, A. Maule, S. McCutcheon, D. Park, W. Platts, K. Prat, J. Seeb, L. Seeb, and others. 1991. Status of Snake River chinook salmon. Don Chapman Consultants, Inc., Boise, Idaho, for Pacific Northwest Utilities Conference Committee.

Chapman, D., C. Pevan, T. Hillman, A. Giorgi, and F. Utter. 1994. Status of summer steelhead in the mid-Columbia River. Don Chapman Consultants, Inc., Boise, Idaho.

Chapman, D., C. Peven, A. Giorgi, T. Hillman, and F. Utter. 1995. Status of spring chinook salmon in the mid-Columbia River. Don Chapman Consultants, Inc., Boise, Idaho.

Chilcote, M. W. 1997. Conservation status of steelhead in Oregon. Oregon Department of Fish and Wildlife, Draft Report, Portland. (September 9)

Clark, C., and J.E. Shelbourn. 1985. Growth and Development of Seawater Adaptability by Juvenile Fall Chinook Salmon (*Oncorhynchus tshawytscha*) in Relation to Temperature. Aquaculture 45:21-31.

Collis, K., R.E. Beaty and B.R. Crain. 1995. Changes in Catch Rate and Diet of Northern Squawfish Associated With the Release of Hatchery-Reared Juvenile Salmonids in a Columbia River Reservoir. North American Journal of Fisheries Management 15:346-357.

Congleton, J.L., S.K. Davis, and S.R. Foley. 1981. Distribution, Abundance and Outmigration Timing of Chum and Chinook Salmon Fry in the Skagit Salt Marsh, in Salmon and Trout Migratory Behavior Symposium, edited by E.L. Brannon and E.O. Salo, pp. 153-163. University of Washington, Seattle.

Cooney, T. D. 2000. UCR steelhead and spring chinook salmon quantitative analysis report. Part 1: run reconstructions and preliminary assessment of extinction risk. Technical Review Draft. National Marine Fisheries Service, Hydro Program, Portland, Oregon.

Corps (U.S. Army Corps of Engineers). 1999. Columbia River Channel Improvement Study – Final Integrated Feasibility Report and Environmental Impact Statement. August 1999.

Craddock, D.R., T.H. Blahm, and W.D. Parente. 1976. Occurrence and Utilization of Zooplankton by Juvenile Chinook Salmon in the Lower Columbia River. Transactions of the American Fisheries Society 105:72-76.

Cudaback, C. N. and D. A. Jay. 1996. Buoyant plume formation at the mouth of the Columbia River -- an example of internal hydraulic control?, Buoyancy Effects on Coastal and Estuarine Dynamics, AGU Coastal and Estuarine Studies 53: 139-154.

Danehy, R.J. and N.H. Ringler. 1991. Ecology of smallmouth bass (*Micropterus dolomieui*) in the nearshore of Mexico Bay, Lake Ontario. Pages 66-72, in D.C. Jackson (ed), The First International Smallmouth Bass Symposium. Southern Division American Fisheries Society. Bethesda, Maryland.

Dawley, E.M., R.D. Ledgerwood, T.H. Blahm, C.W. Sims, J.T. Durkin, R.A. Kirn, A.E. Rankis, G.E. Monan and F.J. Ossiander. 1986. Migrational Characteristics, Biological Observations, and Relative Survival of Juvenile Salmonids Entering the Columbia River Estuary. Final Report of Research. Bonneville Power Administration Contract DE-AI79-84BP39652. Project No. 81-102. 256 pp.

DeVore, P. W., L. T. Brooke, and W. A. Swenson. 1980. The Effects of Red Clay Turbidity and Sedimentation on Aquatic Life In the Nemadji River System. Impact of Nonpoint Pollution Control on Western Lake Superior. EPA Report 905/9-79-002-B. U.S. Environmental Protection Agency, Washington, D.C.

Dunsmoor, L.K., D.H. Bennett, and J.A. Chandler. 1991. Prey selectivity and growth of a planktivorous population of smallmouth bass in an Idaho reservoir. Pages 14-23 in D.C. Jackson (ed), The First International Smallmouth Bass Symposium. Southern Division American Fisheries Society. Bethesda, Maryland.

Edwards, E.A., G. Gebhart and O.E. Maughan. 1983. Habitat suitability information: smallmouth bass. U.S. Dept. Int., Fish Wildl. Ser. FWS/OBS-82/10.36. 47pp.

Ellis, C.H. 1957. Effect of Salt Water Rearing on Survival of Fall Chinook Salmon. Unpublished Report. Washington State Department of Fisheries (now Department of Fish and Wildlife), Olympia, Washington. 12pp.

Evermann, B. W. 1895. A preliminary report upon salmon investigations in Idaho in 1894. U.S. Fish Commission Bulletin 15:253-284.

Fisher, J.P., and W.G. Pearcy. 1990. Distribution and Residence Times of Juvenile Fall and Spring Chinook Salmon in Coos Bay, Oregon. Fishery Bulletin 88:51-58.

Franklin, J. F., and C. T. Dyrness. 1973. Natural vegetation of Oregon and Washington. U.S. Department of Agriculture, Pacific Northwest Forest and Range Experiment Station, USDA Forest Service General Technical Report PNW-8, Portland, Oregon.

Fulton, L. A. 1968. Spawning areas and abundance of chinook salmon, *Oncorhynchus tshawytsch*a, in the Columbia River basin – past and present. U.S. Fish and Wildlife Service, Special Scientific Report, Fisheries 571:26.

Gilliland, E., R. Horton, B. Hysmith and J. Moczygemba. 1991. Smallmouth bass in Lake Texoma, a case history. Pages 136-142 in D.C. Jackson (ed), The First International Smallmouth Bass Symposium. Southern Division American Fisheries Society. Bethesda, Maryland.

Giorgi, A.E., D.R. Miller and B.P. Sandford. Migratory characteristics of juvenile ocean-type chinook salmon, *Oncorhynchus tshawytscha*, in John Day Reservoir on the Columbia River. Fishery Bulletin 92:872-879.

Gustafson, R. G., T. C. Wainwright, G. A. Winans, F. W. Waknitz, L. T. Parker, and R. S. Waples. 1997. Status review of sockeye salmon from Washington and Oregon. National Marine Fisheries Service, Northwest Fisheries Science Center, NOAA Technical Memorandum NMFS-NWFSC-33, Seattle, Washington.

Gray, G.A. and D.W. Rondorf. 1986. Predation on juvenile salmonids in Columbia Basin reservoirs. Pages 178-185 in G.E. hall and M.J. Van Den Avle eds. Reservoir Fisheries Management Strategies for the 80's. Southern Division American Fisheries Society, Bethesda, Maryland.

Gregory, R. S. 1993. Effect of turbidity on the predator avoidance behavior of juvenile chinook salmon (Oncorhynchus tshawytcha). Canadian Journal of Fisheries and Aquatic Sciences 50:241-246.

Gregory, R. S., and C. D. Levings. 1998. Turbidity Reduces Predation on Migrating Juvenile Pacific Salmon. Transactions of the American Fisheries Society 127: 275-285.

Hassemer, P. F. 1992. Run composition of the 1991-92 run-year Snake River steelhead measured at Lower Granite Dam. Idaho Fish and Game, Boise, to National Oceanic and Atmospheric Administration (Award NA90AA-D-IJ718).

Hayman, R.A., E.M. Beamer, and R.E. McClure. 1996. FY 1995 Skagit River Chinook Restoration Research. Report by Skagit System Cooperative, LaConner, Washington. 54pp. plus appendices.

Healey, M.C. 1980. Utilization of the Nanaimo River Estuary by Juvenile Chinook Salmon, *Oncorhynchus tshawytscha*. Fishery Bulletin 77:653-668

Healey, M.C. 1982. Juvenile Pacific Salmon in Estuaries: the Life Support System. In Estuarine Comparisons, edited by V.S. Kennedy, pp. 315-341. Academic Press, New York, New York.

Healey, M. C. 1983. Coastwide distribution and ocean migration patterns of stream- and ocean-type chinook salmon, *Oncorhynchus tshawytsch*a. Canadian Field-Naturalist 97:427-433.

Healey, M.C. 1991. Life history of chinook salmon (*Oncorhynchus tshawytscha*). Pages 311-393 *In:* Groot, C. and L. Margolis (eds.). 1991. Pacific salmon life histories. Vancouver, British Columbia: University of British Columbia Press.

Herrmann, R.B. 1970. Food of Juvenile Chinook and Chum Salmon in the Lower Chehalis River and Upper Grays Harbor. In Grays Harbor Cooperative Water Quality Study 1964-1966. Washington State Department of Fisheries, Technical Report 7. pp. 59-82.

Hickey, B. M., L. J. Pietrafesa, D. A. Jay, and W. C. Boicourt. 1997. The Columbia River plume study: subtidal variability in the velocity and salinity field, in press, J. of Geophys. Res.

Higgs, D.A., J.S. MacDonald, C.D. Levings, and B.S. Dosanjh. 1995. Nutrition and Feeding Habits in Relation to Life History Stage. In Physiological Ecology of Pacific Salmon, edited by C. Groot, L. Margolis, and W.C. Clarke, pp. 154-315. University of British Columbia Press, Vancouver, British Columbia.

Holton, R.L., and D.L. Higley. 1984. Salinity-Temperature Relations of the Amphipod Corophium Salmonis in the Columbia River Estuary. Unpublished report, Oregon State University to U.S. Army Corps of Engineers, Portland, Oregon. 36 pp.

Howell, P., K. Jones, D. Scarnecchia, L. LaVoy, W. Knedra, and D. Orrmann. 1985. Stock Assessment of Columbia River Anadromous Salmonids (Project 83-335, 2 volumes), Final Report to Bonneville Power Administration, Portland, Oregon.

Irving, J. S., and T. C. Bjornn. 1981. Status of Snake River fall chinook salmon in relation to the Endangered Species Act. Idaho Cooperative Fishery Research Unit, University of Idaho, Moscow, for U.S. Fish and Wildlife Service.

Jackson, P. L. 1993. Climate. Pages 48-57 *in* P. L. Jackson and A. J. Kimerling, editors. Atlas of the Pacific Northwest. Oregon State University Press, Corvallis.

Johnson, O.W., W.S. Grant, R.G. Cope, K. Neely, F.W. Waknitz, and R.S. Waples. 1997. Status review of chum salmon from Washington, Oregon, and California. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-32, 280 p.

Johnson, S.W., J.F. Thedinga, and K. V. Koski. 1992. Life History of Juvenile Ocean-Type Chinook Salmon (*Oncorhynchus tshawytscha*) in the Situk River, Alaska. Canadian Journal of Fisheries and Aquatic Science 49:2621-2629.

Kahler, T., M. Grassley and D. Beauchamp. 2000. A summary of the effects of bulkheads, piers and other artificial structures and shorezone development on ESA-listed salmonids in lakes. City of Bellevue, Bellevue, Washington. 74pp.

Kask, B.A., and R.R. Parker. 1972. Observations on Juvenile Chinook Salmon in the Somass River Estuary Port Alberni, B.C. Fisheries Research Board of Canada, Technical Report 308. 15 pp.

Kjelson, M.A., P.F. Raquel, and F.W. Fisher. 1982. Life History of Fall-Run Juvenile Chinook Salmon, *Oncorhynchus tshawytscha,* in the Sacramento-San Joaquin Estuary, California. in Estuarine Comparisons, edited by V.S. Kennedy, pp. 393-411. Academic Press, New York, New York.

Kostow, K, editor. 1995. Biennial report on the status of wild fish in Oregon. Oregon Department of Fish and Wildlife, Portland.

Larkin, P.A. 1979. Predator-prey relations in fishes: an overview of the theory. Pages 13-22 in R.H. Stroud and H. Clepper, editors. Predator-prey systems in fisheries management. Sport Fishing Institute, Washington D.C.

Ledgerwood, R.D., E.M. Dawley, P.J. Bentley, L.G. Gilbreath, T.P. Poe and H.L. Hansen. 1993. Effectiveness of predator removal for protecting juvenile fall chinook salmon released from Bonneville Hatchery, 1991. U.S. Dep. Commerce, NOAA Technical Memorandum NMFS-NWFSC-9. 63pp.

Ledgerwood, R.D., F.P. Thrower and E.M. Dawley. 1991. Diel sampling of migratory juvenile salmonids in the Columbia River estuary. Fishery Bulletin 89:69-78.

Levings, C.D. 1982. Short-Term Use of a Low Tide Refuge in a Sandflat by Juvenile Chinook, (*Oncorhynchus tshawytscha*), Fraser River Estuary. Canadian Technical Report of Fisheries and Aquatic Sciences No. 1111. Department of Fisheries and Oceans, Fisheries Research Branch, West Vancouver, British Columbia.

Levings, C.D., C.D. Mcallister, and B.D. Chang. 1986. Differential Use of the Campbell River Estuary, British Columbia, by Wild and Hatchery-Reared Juvenile Chinook Salmon (*Oncorhynchus tshawytscha*). Canadian Journal of Fisheries and Aquatic Sciences 43:1386-1397.

Levy, D.A., and T.G. Northcote. 1982. Juvenile Salmon Residency in a Marsh Area of the Fraser River Estuary. Canadian Journal of Fisheries and Aquatic Sciences 39:270-276.

Levy, D.A., T.G. Northcote, and G.J. Birch. 1979. Juvenile Salmon Utilization of Tidal Channels in the Fraser River Estuary. Technical Report No. 23. Westwater Research Centre, University of British Columbia, Vancouver. 70 pp.

Lloyd, D. S. 1987. Turbidity as a water quality standard for salmonid habitats in Alaska. North American Journal of Fisheries Management 7:34-45.

Lloyd, D. S., J. P. Koenings, and J. D. LaPerriere. 1987. Effects of Turbidity in Fresh Waters of Alaska. North American Journal of Fisheries Management 7: 18-33.

MacDonald, J. 1960. The Behavior of Pacific Salmon Fry During Their Downstream Migration to Freshwater and Saltwater Nursery Areas. Journal of The Fisheries Research Board of Canada 17:655-676.

MacDonald, J.S., C.D. Levings, C.D. Mcallister, U.H.M. Fagerlund, and J.R. McBride. 1987. A Field Experiment to Test the Importance of Estuaries for Chinook Salmon (*Oncorhynchus tshawytscha*) Survival: Short-Term Results. Canadian Journal of Fisheries and Aquatic Sciences 45:1366-1377.

MacDonald, J.S., I.K. Birtwell, and G.M. Kruzynski. 1986. Food and Habitat Utilization by Juvenile Salmonids in the Campbell River Estuary. Canadian Journal of Fisheries and Aquatic Sciences 45:1366-1377.

Marr, J. C. 1943. Age, length, and weight studies of three species of Columbia River salmon *(Oncorhynchus keta, O. gorbuscha* and *O. kisutc*h). Stanford Ichthyological Bulletin 2:157-197.

Matthews, G.M. and R.S. Waples. 1991. Status review for Snake River spring and summer chinook salmon. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-F/NWC-200, 75 p.

Mattson, C. R. 1948. Spawning ground studies of Willamette River spring chinook salmon. Fish Commission of Oregon Research Briefs 1(2):21-32.

McClure, M., B. Sanderson, E. Holmes, C. Jordan, P. Kareiva, and P. Levin. 2000a. A standardized quantitative analysis of the risks faced by salmonids in the Columbia River basin. National Marine Fisheries Service, Northwest Fisheries Science Center, Cumulative Risk Initiative, Draft Report, Seattle, Washington. April 7.

McClure, B. Sanderson, E. Holmes, C. Jordan, P. Kareiva, and P. Levin. 2000b. Revised Appendix B of standardized quantitative analysis of the risks faced by salmonids in the Columbia River basin. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington. September.

McKernan, D. L,. and C. R. Mattson. 1950. Observations on pulp and paper effluents and the probable effects of this pollutant on the fisheries resources of the Willamette River in Oregon. Fish Commission of Oregon, Fish Commission Research Briefs 3(1):14-21.

McLeay, D. J., G. L. Ennis, I. K. Birtwell, and G. F. Hartman. 1984. Effects On Arctic Grayling (Thymallus arcticus) of Prolonged Exposure to Yukon Placer Mining Sediment: A Laboratory Study. Canadian Technical Report of Fisheries and Aquatic Sciences 1241.

McLeay, D. J., I. K. Birtwell, G. F. Hartman, and G. L. Ennis. 1987. Responses of arctic grayling (Thymallus arcticus) to acute and prolonged exposure to Yukon placer mining sediment. Canadian Journal of Fisheries and Aquatic Sciences 44: 658-673.

Meador, J. 2000. An analysis in support of sediment quality guidelines PCBs for the protection of threatened and endangered salmonids. Internal report, NMFS. Memo from Tracy K. Collier, through John E. Stein, to Steven Landino. September, 2000. Northwest Fisheries Science Center, NMFS, NOAA, Seattle.

Mosisch, T.D. and A.H. arthington. 1998. The impacts of power boating and water skiing on lakes and reservoirs. Lakes & Reservoirs: Research and Management 3:1-17.

Mullan, J. W., A. Rockhold, and C. R. Chrisman. 1992. Life histories and precocity of chinook salmon in the mid-Columbia River. Progressive Fish-Culturist 54:25-28.

Murphy, L.M., J. Heifetz, J.F. Thedinga, S.W. Johnson, and K.V. Koski. 1989. Habitat Utilization by Juvenile Pacific Salmon (*Oncorhynchus*) in the Glacial Taku River, Southeast Alaska. Canadian Journal of Fisheries and Aquatic Sciences 46:1677-1685.

Myers, J.M., R.G. Kope, G.J. Bryant, D. Teel, L.J. Lierheimer, T.C. Wainwright, W.S. Grant, F.W. Waknitz, K. Neely, S.T. Lindley, and R.S. Waples. 1998. Status review of chinook salmon from Washington, Idaho, Oregon, and California. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-35, 443 p.

National Research Council. 1996. Upstream: Salmon and Society in the Pacific Northwest. Committee on Protection and Management of Pacific Northwest Anadromous Salmonids, Board on Environmental Studies and Toxicology, Commission on Life Sciences, National Academy Press, Washington, D.C. 451 pp.

Newcombe, C. P., and D. D. MacDonald. 1991. Effects of Suspended Sediments on Aquatic Ecosystems. North American Journal of Fisheries Management 11: 72-82.

NMFS (National Marine Fisheries Service). 1995. Proposed recovery plan for Snake River salmon. National Marine Fisheries Service, Portland, Oregon. (March 1995)

NMFS (National Marine Fisheries Service). 1999. Biological opinion on artificial propagation in the Columbia River basin – incidental take of listed salmon and steelhead from Federal and non- Federal hatchery programs that collect, rear, and release unlisted fish species. NMFS, Sustainable Fisheries Division, Portland, Oregon. (March 29, 1999)

NMFS (National Marine Fisheries Service). 2000. Biological Opinion on Reinitiation of Consultation on Operation of the Federal Columbia River Power System, Including the Juvenile Fish Transportation Program, and 19 Bureau of Reclamation Projects in the Columbia Basin. NMFS, Hydro Division, Portland, Oregon.

NWFSC (Northwest Fisheries Science Center) Environmental Conservation Division. 2001, in draft. Potential impacts of toxic contaminants in salmonids and prey from the Columbia River estuary. 26 pp.

NWPPC (Northwest Power Planning Council). 1989. Snake River subbasin salmon and steelhead plan. Northwest Power Planning Council, Portland, Oregon.

Northwest Power Planning Council. 1996. Return to the River: Restoration of Salmonid Fishes in the Columbia River Ecosystem. 580 pp.

ODFW (Oregon Department of Fish and Wildlife). 1998a. Memorandum re: harvest rates for Willamette spring chinooks, to J. Martin from S. Sharr, ODFW, Portland. (September 30)

ODFW (Oregon Department of Fish and Wildlife). 1998b. Oregon wild fish management policy. Oregon Department of Fish and Wildlife, Portland, Oregon.

ODFW and WDFW (Oregon Department of Fish and Wildlife and Washington Department of Fish and Wildlife). 1995. Status report, Columbia River fish runs and fisheries, 1938-94. Oregon Department of Fish and Wildlife, Portland, and Washington Department of Fish and Wildlife, Olympia.

Ogden Beeman and Associates. 1997. Site Designs for Upland Disposal, Columbia River Deepening Project. Final Report.

PFMC (Pacific Fishery Management Council). 1999. Amendment 14 to the Pacific Coast Salmon Plan. Appendix A: Description and Identification of Essential Fish Habitat, Adverse Impacts and Recommended Conservation Measures for Salmon. Portland, Oregon.

Petersen, C.J., D.B. Jepsen, R.D. Nelle, R.S. Shively, R.A. Tabor, T.P. Poe. 1990. System-wide Significance of Predation on Juvenile Salmonids in Columbia and Snake River Reservoirs. Annual Report of Research. Bonneville Power Administration Contract DE-AI79-90BP07096. Project No. 90-078. 53 pp.

Pflug, D.E. and G.B. Pauley. 1984. Biology of Smallmouth Bass (*Micropterus dolomieui*) in Lake Sammamish, Washington. Northwest Science 58(2):119-130.

Phelps, S. R., L. L. LeClair, S. Young, and H. L. Blankenship. 1994. Genetic diversity patterns of chum salmon in the Pacific Northwest. Canadian Journal of Fisheries and Aquatic Sciences 51(Suppl. 1):65-83.

Poe, T.P, H.C. Hansel, S. Vigg, D.E. Palmer, and L.A. Prendergast. 1991. Feeding of Predaceous Fishes on Out-Migrating Juvenile Salmonids in John Day Reservoir, Columbia River. Transactions of the American Fisheries Society 120:405-420.

Redding, J. M., C. B. Schreck, and F. H. Everest. 1987. Physiological Effects on Coho Salmon and Steelhead of Exposure to Suspended Solids. Transactions of the American Fisheries Society 116:737-744.

Reynolds, W.W. and M.E. Casterlin. 1976. Activity rhythms and light intensity preferences of *Micropterus salmoides* and *M. dolomieui*. Transactions of the American Fisheries Society 3:400-403

Rich, W. H. 1942. The salmon runs of the Columbia River in 1938. Fisheries Bulletin 50:103-147.

Rieman, B.E., R.C. Beamesderfer, S. Vigg and T.P. Poe. 1991. Estimated loss of juvenile salmonids to predation by northern squawfish, walleyes and smallmouth bass in John Day Reservoir, Columbia River. Transactions of the American Fisheries Society 120:448-458.

Reimers, P. E., and R. E. Loeffel. 1967. The length of residence of juvenile fall chinook salmon in selected Columbia River tributaries. Fish Commission of Oregon 13:5-19.

Salo, E.O. 1991. Life history of chum salmon (*Oncorhynchus keta*). Pages 231-309 *In:* Groot, C. and L. Margolis (eds.). 1991. Pacific salmon life histories. Vancouver, British Columbia: University of British Columbia Press.

Scannell, P. O. 1988. Effects of Elevated Sediment Levels from Placer Mining on Survival and Behavior of Immature Arctic Grayling. Alaska Cooperative Fishery Unit, University of Alaska. Unit Contribution 27.

Servizi, J. A., and Martens, D. W. 1991. Effects of Temperature, Season, and Fish Size on Acute Lethality of Suspended Sediments to Coho Salmon. Canadian Journal of Fisheries and Aquatic Sciences 49:1389-1395.

Sherwood, C. R., D. A. Jay, R. B. Harvey, P. Hamilton and C. A. Simenstad. 1990. Historical changes in the Columbia river estuary. Progr. Oceanogr. 25: 299-352.

Shreffler, D.K., C.A. Simenstad, and R.M. Thom. 1992. Temporary Residence by Juvenile Salmon in a Restored Estuarine Wetland. Canadian Journal of Fisheries and Aquatic Sciences 47:2079-2084.

Sibert, J.R. 1975. Residence of Juvenile Salmonids in the Nanaimo River Estuary. Environment Canada, Fisheries and Marine Service, Technical Report No. 537. 23 pp.

Sigler, J. W. 1988. Effects of chronic turbidity on anadromous salmonids: recent studies and assessment techniques perspective. Pages 26-37 *in* C. A. Simenstad, editor. Effects of Dredging on Anadromous Pacific Coast Fishes. Washington Sea Grant Program, Washington State University, Seattle.

Simenstad, C.A., K.L. Fresh, and E.O. Salo. 1982. The Role of Puget Sound and Washington Coastal Estuaries in the Life History of Pacific Salmon: An Unappreciated Function. In Estuarine Comparisons, edited by V.S. Kennedy, pp. 343-364. Academic Press, New York New York.

Simenstad C.A., L.F. Small, and C.D. McIntire. 1990. Consumption Processes and Food Web Structure in the Columbia River Estuary. Progress in Oceanography 25:271-297

Simmons, D. 2000. Excel spreadsheet: Snake River fall chinook, annual adult equivalent exploitation rates (AEQ Catch/[AEQ Catch + Escapement]) adjusted to joint staff estimates of ocean escapement. E-mail. National Marine Fisheries Service, Sustainable Fisheries Division, Seattle, Washington.

Spence, B. C., G. A. Lomnicky, R. M. Hughes, and R. P. Novitzki. 1996. An ecosystem approach to salmonid conservation. TR-4501-96-6057. ManTech Environmental Research Services, Corvallis, Oregon.

Stober, Q.J., S.J. Walden, and D.T. Griggs. 1971. Juvenile Salmonid Migration Through North Skagit Bay. In Biological Studies of Kiket Island Nuclear Power Site, edited by Q.J. Stober and E.O. Salo, pp. 35-69. Second Annual Report by Fisheries Research Institute, University of Washington, Seattle.

Tabor, R.A., R.S. Shively and T.P. Poe. 1993. Predation on juvenile salmonids by smallmouth bass and northern squawfish in the Columbia River near Richland, Washington. North American Journal of Fisheries Management 13:831-838.

Thomas, D.W. 1983. Changes in the Columbia River Estuary Habitat Types Over the Past Century. Columbia River Estuary Study Taskforce (CREST) Columbia River Estuary Data Development Program, Astoria, Oregon. 51 pp.

Tiffan, K.F., D.W. Rondorf, and P.G. Wagner. 2000. Physiological Development and Migratory Behavior of Subyearling Fall Chinook Salmon in the Columbia River. North American Journal of Fisheries Management 20:28-40.

Varanasi, U., E. Casillas, M. R. Arkoosh, T. Hom, D. A. Misitano, D. W. Brown, S-L Chan, T. L. Collier, B. B. McCain and J. E. Stein. 1993. Contaminant exposure and associated biological effects in juvenile chinook salmon (Oncorhynchus tshawytscha) from urban and nonurban estuaries of Puget Sound, U.S. Dep. Commer., NOAA Tech. Memo. NMFS-NWFSC-8, p. 112.

Vigg, S., T.P. Poe, L.A. Prendergat and H.C. Hansel. 1991. Rates of consumption of juvenile salmonids and alternative prey fish by northern squawfish, walleyes, smallmouth bass and channel catfish in John Day Reservoir, Columbia River. Transactions of the American Fisheries Society 120:421-438.

Wagner, H.H., F.P. Conte, and J.L. Fessler. 1969. Development of Osmotic and Ionic Regulation in Two Races of Chinook Salmon *Oncorhynchus tshawytscha*. Comparative Biochemistry and Physiology 29: 325-341.

Waples, R.S., O.W. Johnson, and R.P. Jones, Jr. 1991a. Status review for Snake River sockeye salmon. U.S. Dept. Commer., NOAA Tech. Memo. NMFS F/NWC-195. 23 p.

Waples, R.S., R.P. Jones, Jr., B.R. Beckman, and G.A. Swan. 1991b. Status review for Snake River fall chinook salmon. U.S. Dept. Commer., NOAA Tech. Memo. NMFS F/NWC-201. 73 p.

Waples, R. S. 1999. Dispelling some myths about hatcheries. Fisheries 24(2):12-21.

Ward, D.L. and A.A. Nigro. 1992. Differences in Fish Assemblages Among Habitats Found in the Lower Willamette River, Oregon: Application of and Problems With Multivariate Analysis. Fisheries Research 13:119-132.

Ward, D.L., A.A. Nigro, R.A. Farr, and C.J. Knutsen. 1994. Influence of Waterway Development on Migrational Characteristics of Juvenile Salmonids in the Lower Willamette River, Oregon. North American Journal of Fisheries Management 14:362-371.

WDF, WDW, and WWTIT (Washington Department of Fisheries, Washington Department of Wildlife, and Western Washington Treaty Indian Tribes). 1993. Washington state salmon and steelhead stock inventory (SASSI), 1992. Washington Department of Fisheries, Washington Department of Wildlife and Western Washington Treaty Indian Tribes. Olympia.

Weitkamp, L.A. 1994. A Review of the Effects of Dams on the Columbia River Estuary Environment, with Special Reference to Salmonids. Bonneville Power Administration, Portland, Oregon.

Whitt, C. R. 1954. The age, growth, and migration of steelhead trout in the Clearwater River, Idaho. Master's thesis. University of Idaho, Moscow.

Zimmerman, M.P. 1999. Food habits of smallmouth bass, walleyes and northern pikeminnow in the lower Columbia River Basin during outmigration of juvenile anadromous salmonids. Transactions of the American Fisheries Society 128:1036-1054.

Zimmerman, M.P. and D.L. Ward. 1999. Index of predation on juvenile salmonids by northern pikeminnow in the lower Columbia River Basin, 1994-1996. Transactions of the American Fisheries Society 128:995-1007.